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SITE-SPECIFIC TECHNICAL REPORT FOR BIOSLURPER TESTING AT THE FIRE TRAINING AREA 23, TYNDALL AFB, FLORIDA

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

BIOSLURPER TESTING AT TYNDALL AFB, FLORIDA

by

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June 30, 1996

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EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Tyndall AFB for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Tyndall AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe, and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Tyndall AFB is one of more than 40 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Tyndall AFB were skimmer pumping, bioslurping, and drawdown pumping.

Bioslurper pilot test activities were conducted at two locations at Fire Training Area 23 (Site FT-23): (1) monitoring well MW-5, and (2) monitoring wells EW-1 and EW-2. Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-5, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted.

The LNAPL recovery testing was conducted in the following sequence at monitoring well MW-5: 32.5 hours in the skimmer configuration, approximately 97 hours in the bioslurper configuration, 18 hours in the drawdown configuration, and, after a period of approximately 64 hours, an additional 26 hours in the drawdown configuration.

After the initial drawdown pump test at MW-5, a bioslurper pump test was conducted at extraction wells EW-1 and EW-2 by connecting the two extraction wells with a polyvinyl chloride (PVC) tube. The duration of the test was approximately 63 hours.

Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

Less than 5 gallons of LNAPL were recovered during the series of pump tests at monitoring well MW-5. Groundwater was extracted at relatively high rates, ranging from 287 gallons/day during the initial skimmer pump test up to 2,207 gallons/day during the initial drawdown pump test.

During the bioslurper pump test conducted at EW-1 and EW-2, free product recovery rates remained relatively stable at approximately 36 gallons/day. Groundwater recovery rates also remained relatively stable at approximately 1,600 gallons/day. These results demonstrated there was significantly greater free product recovery at monitoring wells EW-1 and EW-2 than at monitoring well MW-5. This difference could be accounted for by differences in well construction or simply differences in geology that affect free product mobility.

Based on the results at monitoring wells EW-1 and EW-2, implementation of bioslurping at Site FT-23 may facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

BIOSLURPER TESTING AT TYNDALL AFB, FLORIDA

June 7, 1996

1.0 INTRODUCTION

This report describes activities performed and data collected during field tests at Tyndall Air Force Base (AFB), Florida, to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery technologies for removal of light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Tyndall AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Tyndall AFB is one of more than 40 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at Tyndall AFB are described in the Site-Specific Test Plan provided in Appendix A.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing

is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Tyndall AFB were skimmer pumping, bioslurping, and drawdown pumping. The specific test objectives, methods, and results for the Tyndall AFB test program are discussed in the following sections.

1.2 Testing Approach

Bioslurper pilot test activities were conducted at two locations at Fire Training Area 23 (Site FT-23): (1) monitoring well MW-5, and (2) monitoring wells EW-1 and EW-2. Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-5, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted. The LNAPL recovery testing was conducted in the following sequence at monitoring well MW-5: 32.5 hours in the skimmer configuration, approximately 97 hours in the bioslurper configuration, 18 hours in the drawdown configuration, and, after a period of approximately 64 hours, an additional 26 hours in the drawdown configuration.

After the initial drawdown pump test at MW-5, a bioslurper pump test was conducted at extraction wells EW-1 and EW-2 by connecting the two extraction wells with a polyvinyl chloride (PVC) tube. The duration of the test was approximately 63 hours.

Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

2.0 SITE DESCRIPTION

Site FT-23 is located at the east side of the flight line. Petroleum was stored at the site in a 10,000-gallon nominal capacity steel aboveground storage tank (AST). The AST is housed on a concrete pad, and is surrounded by a 3-ft-high concrete containment system. The fill port to the AST is located at the southwest corner of the AST containment system. During fire training activities, product is pumped from the AST through the pump house located adjacent to the west side of the AST. Product is pumped to the fire training pit located approximately 130 ft from the pump house through an extensive underground distribution system. Figure 1 shows the locations of monitoring wells and monitoring points at Site FT-23.

The soil at Site FT-23 consists of brown, black, and white, angular to subangular, fine-grained silty sands. An abundance of organic material was observed in the soils. Groundwater typically occurs at approximately 5.5 ft bgs.

There are two principal areas of contamination at Site FT-23. The eastern plume is centered at the south side of the pump house and encompasses the AST and the pump house. The second and larger plume of free-phase hydrocarbons is located to the west of the pump house and was observed along the distribution piping east and extending under the fire training pit.

The results from an OHM (1994) study show that concentrations of benzene in the soils range from 0.06 to 8.7 mg/kg, and concentrations of total petroleum hydrocarbons (TPH) range from 10 to 960 mg/kg. The results from the groundwater samples show that benzene is present in concentrations that range from 0.010 to 0.58 mg/L, and TPH in concentrations that range from 0.26 to 5.5 mg/L.

3.0 BIOSLURPER SHORT-TERM PILOT TEST METHODS

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Tyndall AFB.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring well MW-5 was evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model

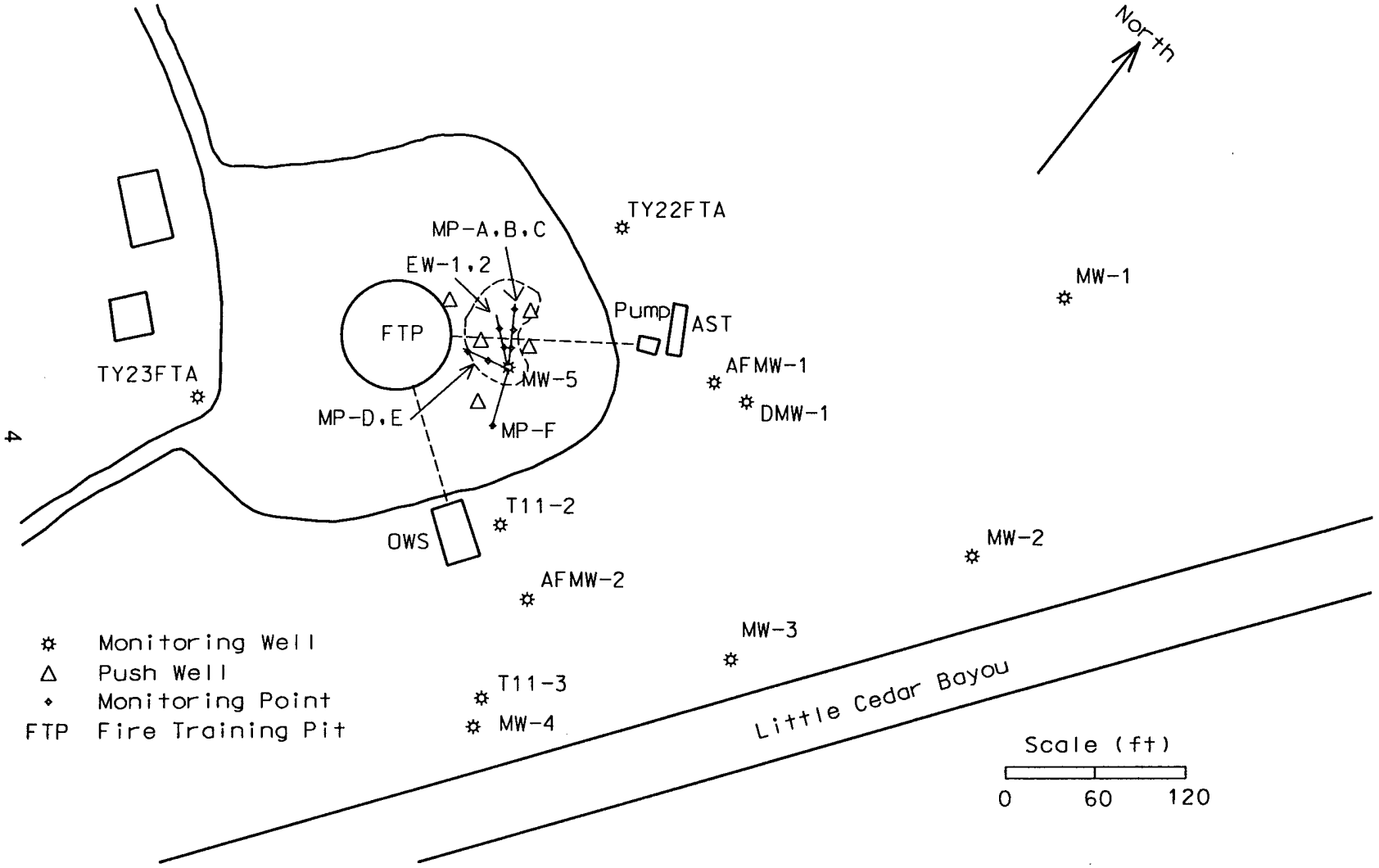

Figure 1. Schematic Diagram Showing Locations of Monitoring Wells and Monitoring Points at Site FT-23, Tyndall AFB, FL

#1068013). LNAPL was removed from the well with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored using the oil/water interface probe for approximately 22 hours.

An LNAPL sample was collected from monitoring well MW-5 for analysis of benzene, toluene, ethylbenzene, and xylenes (BTEX) and for boiling point fractionation. The sample was sent to Alpha Analytical, Inc., in Sparks, Nevada for analysis.

3.2 Well Construction Details

Short-term bioslurper pump tests were conducted at existing monitoring well MW-5 and at installed extraction wells EW-1 and EW-2. Monitoring well MW-5 is constructed of 2-inch-diameter, schedule 40 PVC with a total depth of 15 ft and 10 ft of screen. Extraction wells EW-1 and EW-2 are constructed of 1½-inch-diameter, schedule 40 PVC with a total depth of 8 ft and 3 ft of screen. A schematic diagram illustrating well construction details for monitoring well MW-5 are provided in Figure 2.

3.3 Soil Gas Monitoring Point Installation

Six monitoring points were installed and were labeled MPA, MPB, MPC, MPD, MPE, and MPF. The locations of the monitoring points are illustrated in Figure 1 and construction details are provided in Figure 2.

The monitoring points consisted of ¼-inch tubing, with 1-inch-diameter, 6-inch-long screened areas. The screened lengths were positioned at a depth of 3.0 to 3.5 ft and the annular space corresponding to the screened length was filled with silica sand. The interval from the top of the screened length to the ground surface was filled with bentonite clay chips. After placement, the bentonite clay was hydrated with water to expand the chips and provide a seal.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTech portable O_2/CO_2 meter and a GasTech TraceTechtor portable hydrocarbon meter. Oxygen limitation was observed at all monitoring points with oxygen concentrations ranging from 0 to 5% (Table 1).

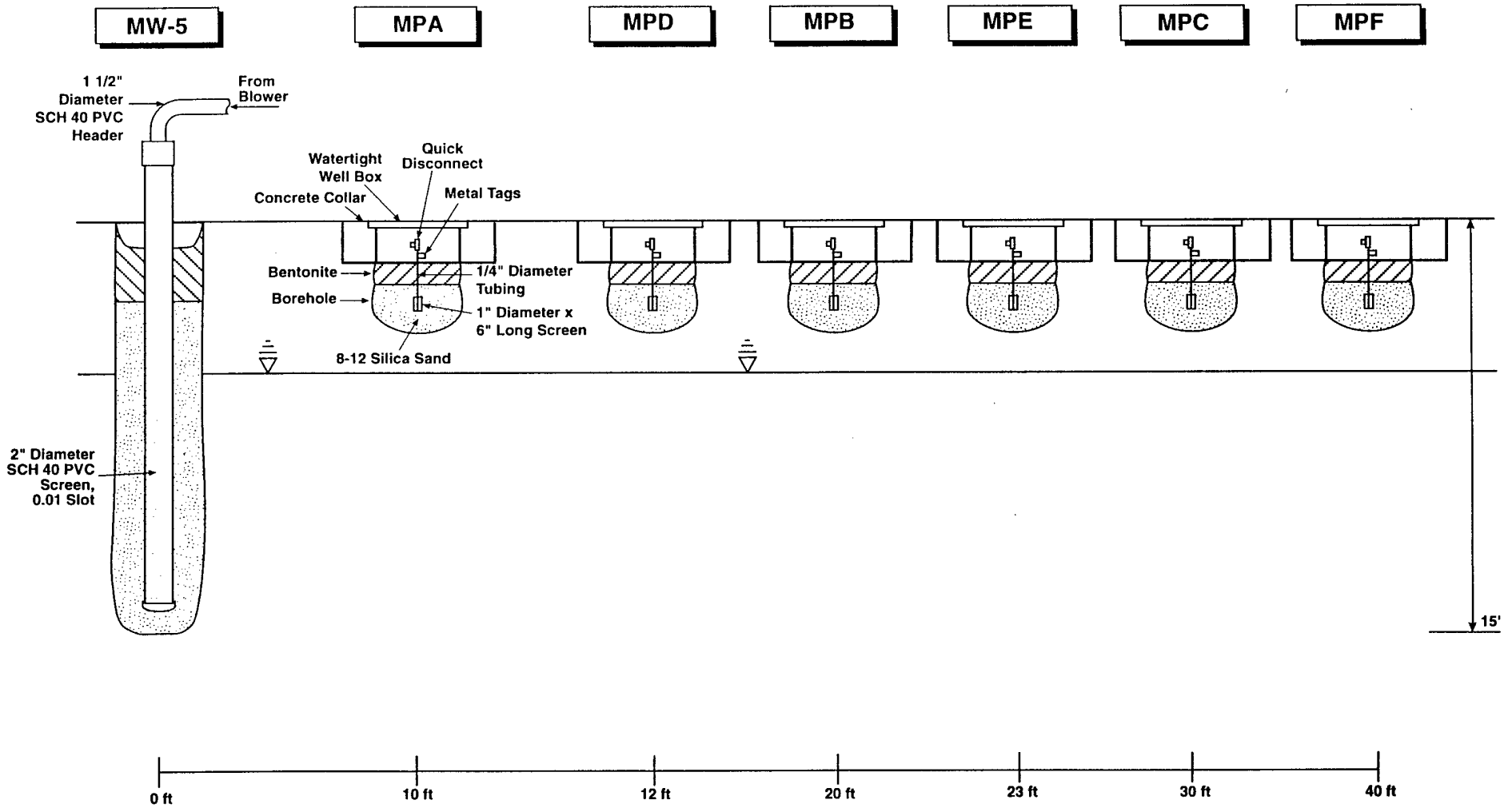

Figure 2. **Construction Details of Monitoring Well MW-5 and Adjacent Soil Gas Monitoring Points at Site FT-23, Tyndall AFB, FL**

F/Leeson/59-3

Table 1. Initial Soil Gas Compositions at Site FT-23, Tyndall AFB, FL

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
MPA	3.5	3.0	11.0	6,400
MPB	3.5	1.5	14.0	2,400
MPC	3.5	0.0	16.0	2,600
MPD	3.5	3.5	7.0	8,000
MPE	3.5	5.0	6.5	>10,000
MPF	3.5	5.0	7.0	>10,000

3.4 Soil Sampling and Analysis

Two soil samples were collected during the installation of monitoring points MPB and MPD and were labeled TYN-S-2 and TYN-S-4. Respective depths for the samples were 2.5 to 3 ft and 4.5 to 5 ft bgs. The soil samples were collected in brass sleeves using a hand-driven sampler. The samples were placed in an insulated cooler, chain-of-custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc., in Sparks, Nevada. Samples were analyzed for (BTEX, moisture content, particle size, pH, porosity, total iron, total Kjeldahl nitrogen, total phosphorus, and TPH). The laboratory analytical report is provided in Appendix B.

3.5 LNAPL Recovery Testing

3.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 7.5-hp liquid ring pump), oil/water separator, and required support equipment were carried to the test location on a trailer. The trailer was located near the monitoring well, the well cap was removed, a coupling and tee were attached to the top of the well, and the slurper tube was lowered into the well. The slurper tube was attached to the vacuum pump. Different configurations of the tee and the placement depth of the slurper tube allow for simulation of

skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping. Extracted groundwater was treated by passing the effluent through an oil/water separator and allowing to settle in a 500-gallon tank followed by a 1,500-gallon tank. The groundwater was discharged hydraulically upgradient of the point of extraction via a sprinkler system to an area which is located within the extent of the free-product plume.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix C. All site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix D.

3.5.2 Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface with the wellhead open to the atmosphere via a PVC connecting tee (Figure 3). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on March 21, 1996, to begin the skimmer pump test. The test was operated continuously for approximately 32.5 hours until a failed generator caused termination of the test. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.5.3 Bioslurper Pump Test

Two bioslurper pump tests were conducted: one at monitoring well MW-5 and one at extraction wells EW-1 and EW-2. Details of the tests are described in the following sections.

3.5.3.1 Monitoring Well MW-5

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper

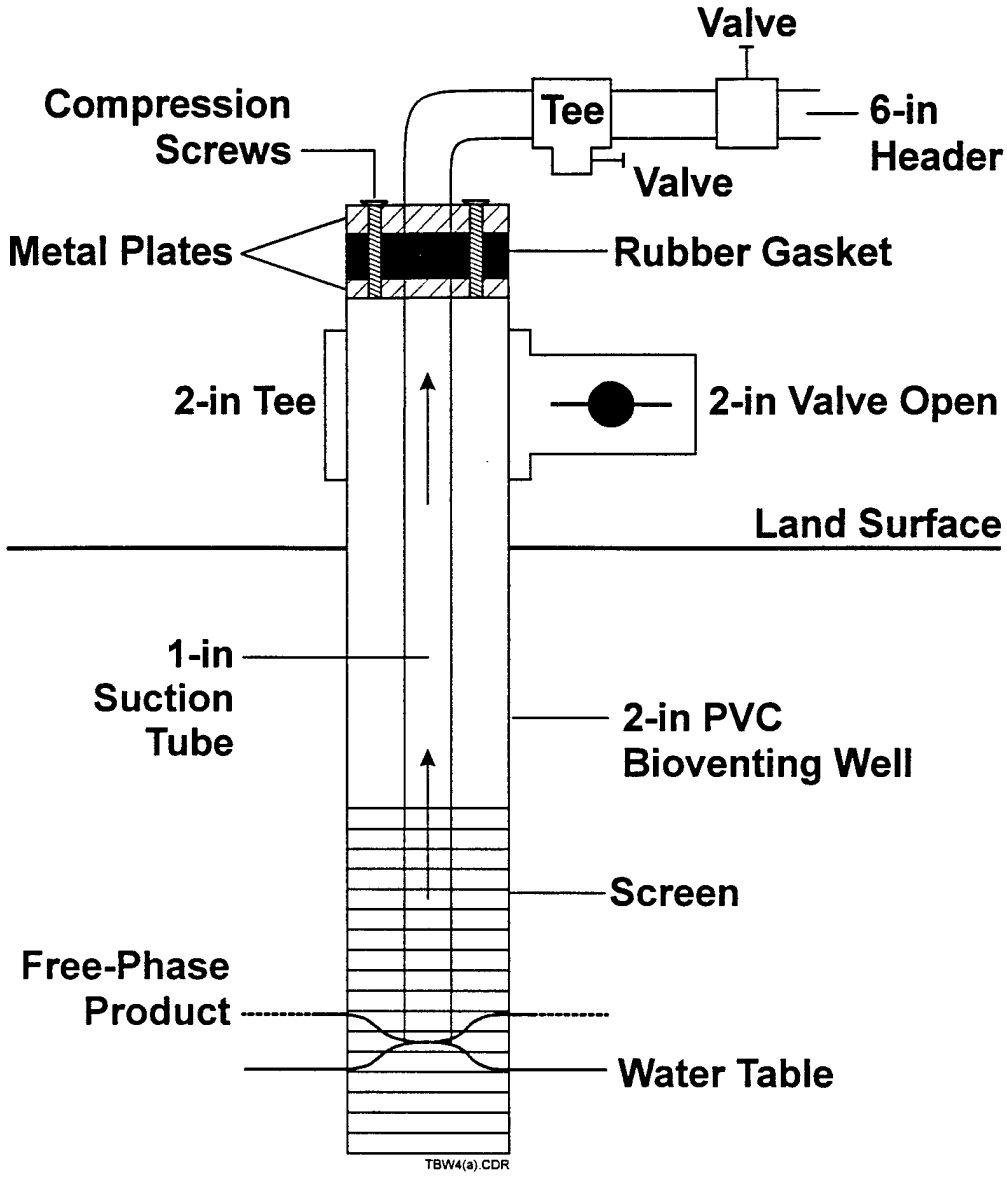

Figure 3. Slurper Tube Placement and Valve Position for the Skimmer Pump Test

tube was then set at the LNAPL/groundwater interface. The PVC connecting tee was removed, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 4). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on March 23, 1996, to begin the bioslurper pump test. The test was initiated approximately 21 hours after the skimmer pump test and was operated for approximately 97 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

3.5.3.2 Extraction Wells EW-1 and EW-2

The bioslurper system setup at EW-1 and EW-2 was modified slightly from that described in Section 3.5.3.1. A PVC pipe extended from EW-2 to EW-1 and then connected to the vacuum pump at the EW-1 side, which allowed the system to operate on both wells simultaneously. The PVC pipe was connected directly to the top of the casing at each of the extraction wells, therefore the vacuum was applied directly to the well without the use of a drop tube. The liquid ring pump was started on March 28, 1996 to begin the bioslurper pump test. The test was initiated approximately 5 minutes after termination of the initial drawdown pump test at MW-5. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

3.5.4 Initial Drawdown Pump Test

Upon completion of the bioslurper pump test, preparations were made to begin the initial drawdown pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was positioned similar to the skimmer configuration, but the pump was operated to achieve drawdown of the water table (Figure 5). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on March 27, 1996, to begin the drawdown pump test at MW-5.

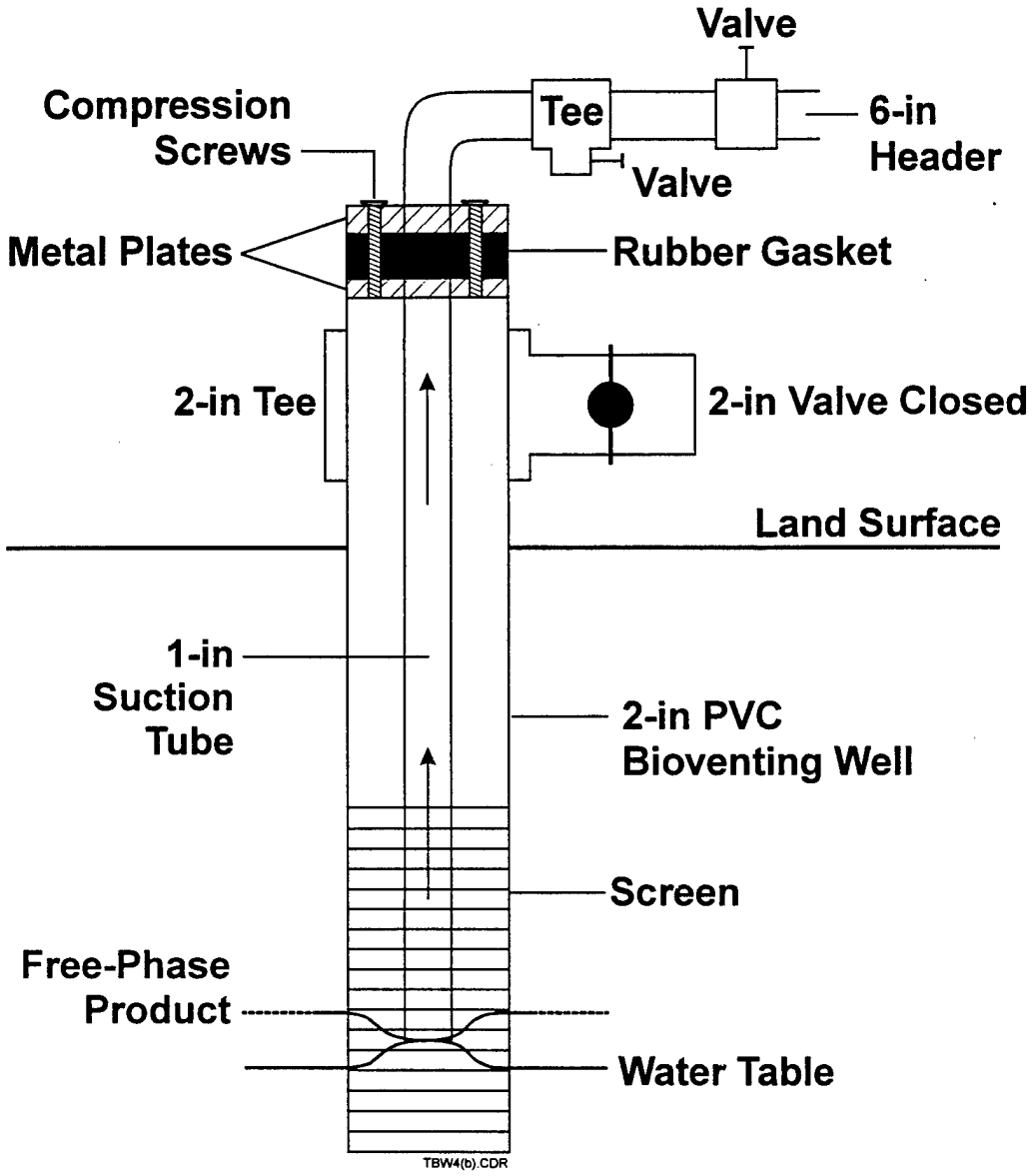

Figure 4. Slurper Tube Placement and Valve Position for the Bioslurper Pump Test

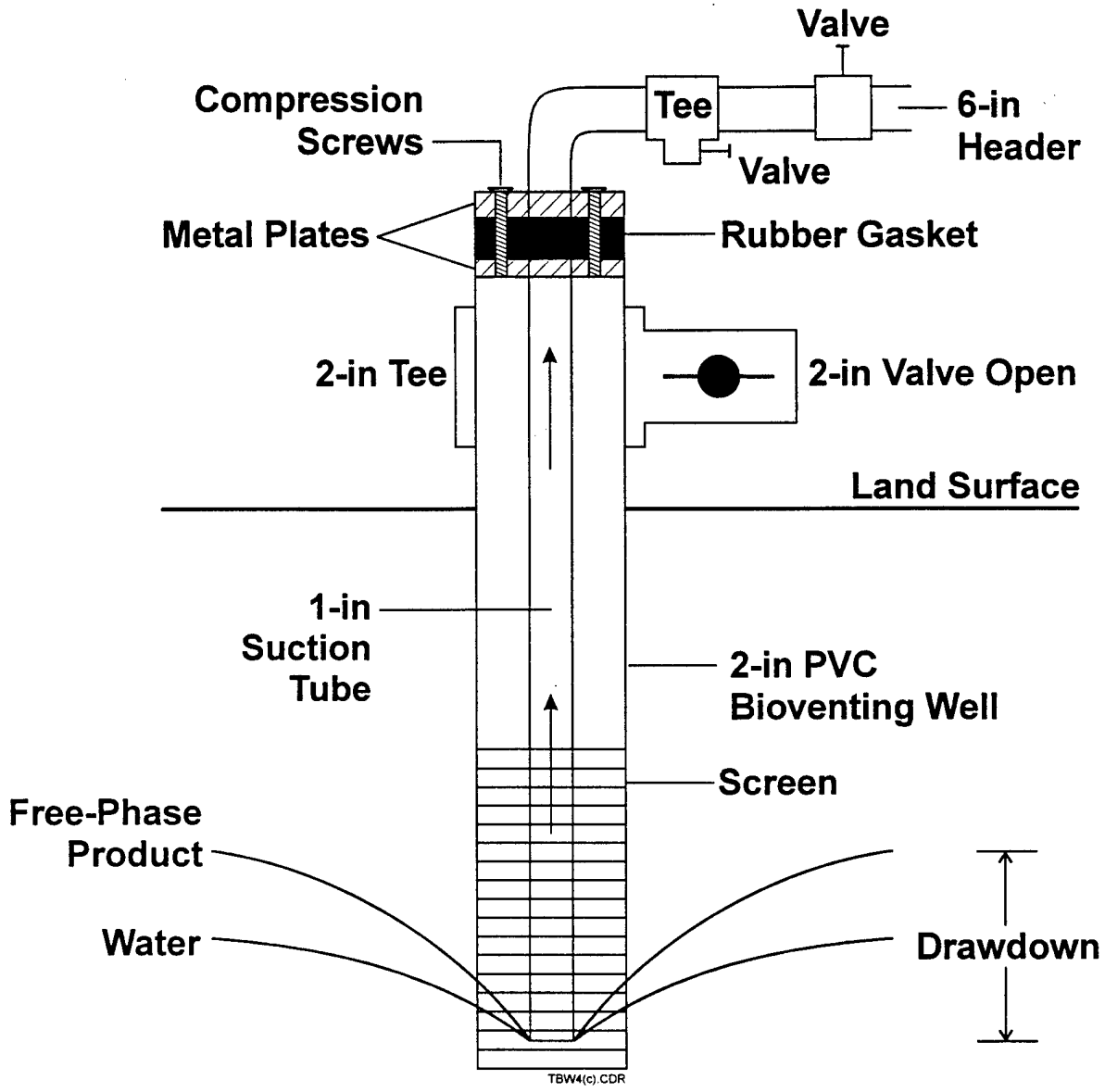

Figure 5. Slurper Tube Placement for the Drawdown Pump Test

The test was initiated approximately 2 hours after the bioslurper pump test and was operated continuously for 18 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix D.

3.5.5 Second Drawdown Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The bioslurper system was set up as described in Section 3.5.4. The liquid ring pump was started on March 31, 1996, to begin the second drawdown pump test. The test was initiated at MW-5 approximately 1 hour after completion of the bioslurper pump test at EW-1 and EW-2 and was operated continuously for approximately 26 hours. The LNAPL and groundwater extraction rates were monitored throughout the tests, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

3.6 Off-Gas Sampling and Analysis

Three soil gas samples were collected during the bioslurper pump tests. Samples TYN-OGS-1 and TYN-OGS-2 were collected from the bioslurper off-gas during the bioslurper pump test at monitoring well MW-5. TYN-OGS-1 was taken while the system was operating at a high flowrate, and TYN-OGS-2 was taken while operating at a low flowrate. Sample TYN-OGS-3 was collected from the bioslurper off-gas during the bioslurper pump test at monitoring wells EW-1 and EW-2. The samples were collected in Tedlar™ bags and transferred to Summa™ canisters. The samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, Florida, for analyses of BTEX and TPH.

3.7 Groundwater Sampling and Analysis

Three groundwater samples were collected during the bioslurper pump test. Two samples were collected from the sprinkler discharge from MW-5 and were labeled TYN-DW-1 and TYN-DW-2. One sample was collected from the sprinkler discharge from EW-1 and EW-2 and was labelled TYN-DW-3. Samples were collected in 40-mL septa vials containing HCl preservative. Samples

were checked to ensure no headspace was present and were then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH.

3.8 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test. Before a vacuum was established in the extraction well, the initial soil gas pressures at the six installed monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the six monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix E.

3.9 In Situ Respiration Testing

Air containing approximately 2% helium was injected into four monitoring points for approximately 25 hours beginning on March 31, 1996. The setup for the in situ respiration test is described in the *Test Plan and Technical Protocol a Field Treatability Test for Bioventing* (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through monitoring points MPA, MPB, MPD, and MPE. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, TPH, and helium were monitored periodically. The respiration test was terminated on April 2, 1996. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix F.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributable to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicated leakage. A gradual loss of helium along with a first-order curve generally indicated diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium

diffuses approximately 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations at test completion are at least 50 to 60% of the initial levels, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

4.0 RESULTS

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Tyndall AFB.

4.1 Baildown Test Results

Results from the baildown test in monitoring well MW-5 are presented in Table 2. A total volume of 5.75 L (1.5 gallons) was removed by hand-bailing from monitoring well MW-5. The LNAPL thickness recovered to approximately 56% of initial levels by the end of the 22-hour test period. The results of these tests indicate that this well may be suitable for bioslurping.

4.2 Soil Sample Analyses

Table 3 shows the TPH and BTEX concentrations measured in soil samples collected from Site FT-23. TPH and BTEX concentrations varied widely between the two samples. Maximum concentrations of TPH and BTEX were 15,000 mg/kg and 693 mg/kg, respectively, in one of the samples; whereas concentrations of TPH and most BTEX components were found to be below detection limits in the second soil sample. The results of the physical characterization and inorganic analyses of the soil are presented in Table 4.

Table 2. **Results of Baildown Testing in Monitoring Well MW-5, Site FT-23, Tyndall AFB, FL**

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 3/20/96-0950	6.89	4.25	2.64
3/20/96-1024	5.33	4.91	0.42
3/20/96-1025	5.31	4.89	0.42
3/20/96-1032	5.26	4.83	0.43
3/20/96-1049	5.23	4.79	0.44
3/20/96-1120	5.35	4.76	0.59
3/20/96-1221	5.48	4.66	0.82
3/20/96-1515	5.59	4.60	0.99
3/20/96-1655	5.64	4.60	1.04
3/21/96-0809	6.17	4.70	1.47

Table 3. **TPH and BTEX Concentrations in Soil Samples from Site FT-23, Tyndall AFB, FL**

Parameter	Concentration (mg/kg)	
	TYN-S-2	TYN-S-4
TPH as diesel	<10	15,000
Benzene	0.051	74
Toluene	<0.020	140
Ethylbenzene	<0.020	69
Xylenes	<0.020	410

Table 4. Physical Characterization and Inorganic Analyses of Soil from Site FT-23, Tyndall AFB, FL

Parameter		Sample	
		TYN-S-2	TYN-S-4
Moisture Content (%)		18.5	14.1
Porosity (%)		60.7	51.7
Total Iron (mg/kg)		1,100	530
Total Kjeldahl Nitrogen (mg/kg)		< 100	580
Total Phosphorus (mg/kg)		40	12
Particle Size	Sand	93.2	93.2
	Silt	0.0	0.0
	Clay	6.8	6.8

4.3 LNAPL Pump Test Results

4.3.1 Pump Test Results at Monitoring Well MW-5

The LNAPL thickness prior to each pump test was measured and is presented in Table 5. Less than 5 gallons of LNAPL were recovered during the series of pump tests at this monitoring well (Table 6). LNAPL recovery rates ranged from 0.13 gallons/day during the bioslurper pump test to 1.65 gallons/day during the skimmer pump test (Figure 6). Groundwater was extracted at relatively high rates, ranging from 287 gallons/day during the initial skimmer pump test up to 2,207 gallons/day during the initial drawdown pump test (Table 6). These results indicate that free product recovery was minimal at this monitoring well possibly due to the relative immobility of the free product.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations remained relatively low throughout the duration of the test (Table 7).

Table 5. Depths to Groundwater and LNAPL Prior to Each Pump Test at Monitoring Well MW-5

Test	Test Start Date	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
Skimmer Pump Test	3/21/96	4.70	6.17	1.47
Bioslurper Pump Test	3/23/96	5.48	5.52	0.040
Initial Drawdown Test	3/27/96	NM	NM	NM
Second Drawdown Test	3/31/96	6.10	6.20	0.10

NM = Not measured.

Table 6. Pump Test Results at Monitoring Well MW-5, Site FT-23, Tyndall AFB, FL

Recovery Rate (gal/day)	Skimmer Pump Test		Bioslurper Pump Test		Initial Drawdown Pump Test		Second Drawdown Pump Test	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
Day 1	2.30	312	0.05	1,107	0.68	2,207	0.93	1,451
Day 2	0.24	233	0.01	875	NA	NA	NA	NA
Day 3	NA	NA	0.01	931	NA	NA	NA	NA
Day 4	NA	NA	0.44	1,896	NA	NA	NA	NA
Average	1.65	287	0.13	1,203	0.68	2,207	0.93	1,451
Total Recovery (gal)	2.23	388	0.52	4,867	0.52	1,683	1.0	1,554

NA = Not applicable.

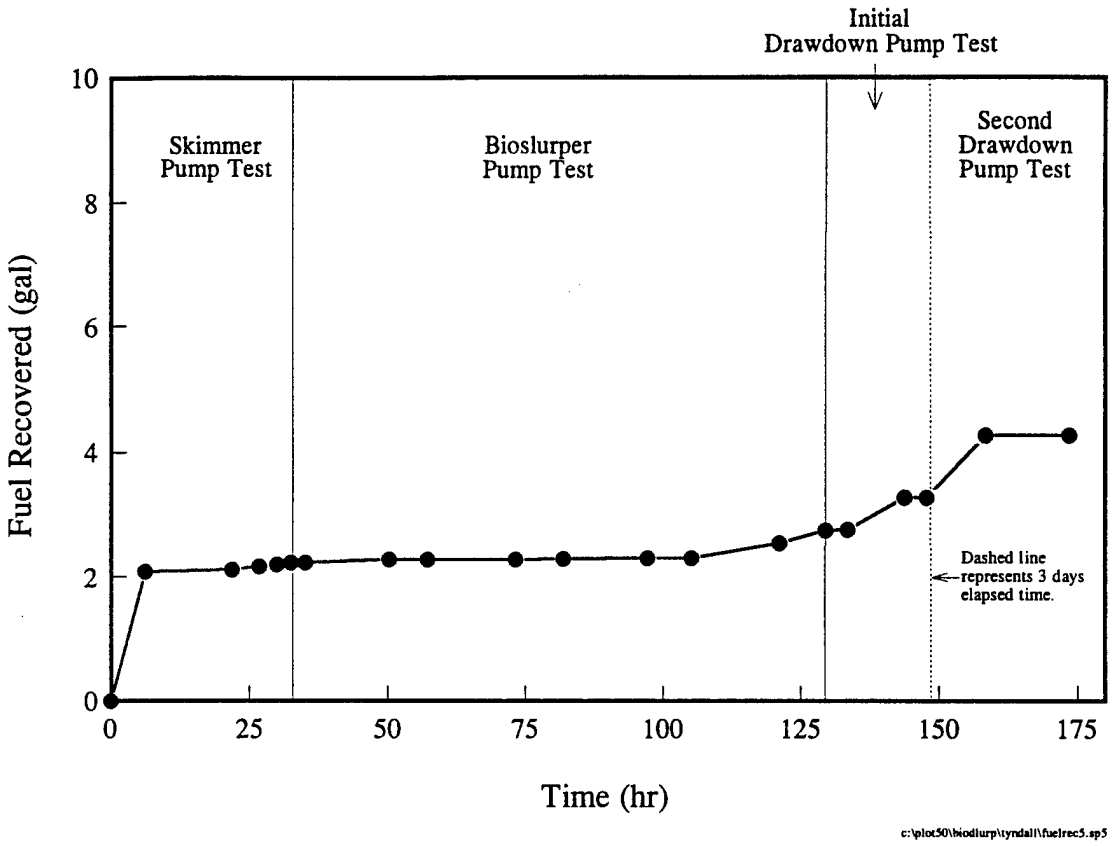

Figure 6. Fuel Recovery Versus Time During Each Pump Test in Monitoring Well MW-5

Table 7. Oxygen Concentrations During the Bioslurper Pump Test at MW-5, Site FT-23, Tyndall AFB, FL

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)						
	0	19	26	42	50	65	73
MPA	3.0	1.0	3.0	2.0	2.0	0.0	0.0
MPB	1.5	1.0	1.0	1.0	1.0	0.0	0.0
MPC	0.0	0.0	0.0	1.0	0.0	0.0	0.0
MPD	3.5	1.0	1.0	0.0	0.0	1.0	0.0
MPE	5.0	1.0	0.0	0.0	0.0	0.5	0.0
MPF	5.0	0.0	1.0	0.5	0.0	0.0	0.0

4.3.2 Bioslurper Pump Test Results at Extraction Wells EW-1 and EW-2

During the bioslurper pump test conducted at EW-1 and EW-2, free product recovery rates remained relatively stable at approximately 36 gallons/day (Table 8). This is a significant increase in LNAPL recovery from that seen at MW-5 (Figure 7). The LNAPL recovery rate versus time is shown in Figure 8.

4.3.3 Extracted Groundwater, LNAPL, and Off-Gas Analyses

Groundwater samples were collected during the bioslurper pump tests at both MW-5 and at EW-1 and EW-2. Average TPH and BTEX concentrations at MW-5 were 11 mg/L and 1.0 mg/L, respectively. Concentrations at EW-1 and EW-2 were considerably higher with a TPH concentration of 100 mg/L and a BTEX concentration of 16 mg/L (Table 9).

Off-gas samples from the bioslurper system also were collected during the bioslurper pump test. The results from the off-gas analyses are presented in Table 10. The bioslurper pump at monitoring well MW-5 was operated at high and low flowrates. Given a vapor discharge rate of 67 scfm and using a concentration of 3,600 ppmv TPH and 31 ppmv benzene, approximately 90 lb/day of TPH and 0.60 lb/day benzene were emitted to the air during the high flowrate portion of the bioslurper pump test. At a reduced vapor discharge rate of 6 scfm and using a concentration of

Table 8. Bioslurper Pump Test Results at Monitoring Wells EW-1 and EW-2, Site FT-23, Tyndall AFB, FL

Recovery Rate (gal/day)	LNAPL	Groundwater
Day 1	39.8	1,770
Day 2	32.7	1,495
Day 3	36.4	1,475
Average	36.1	1,593
Total Recovery (gal)	95.0	4,188

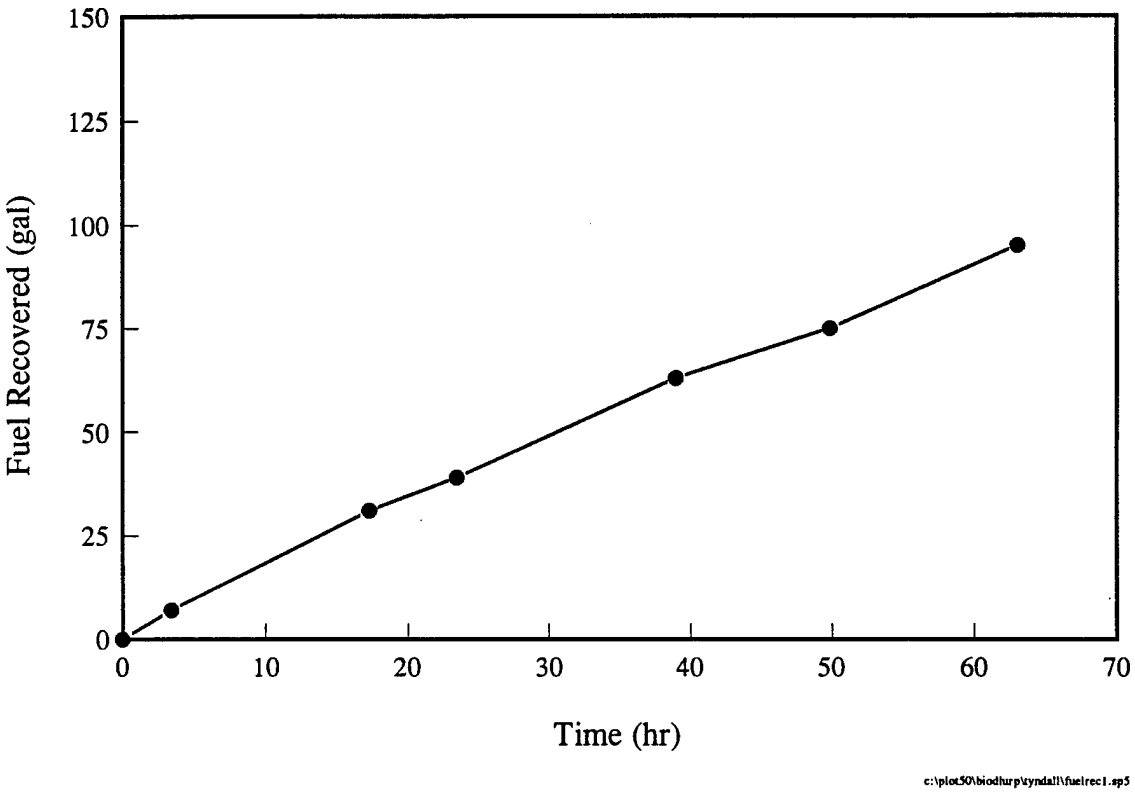

Figure 7. **Fuel Recovery Versus Time During the Bioslurper Pump Test in Extraction Wells EW-1 and EW-2**

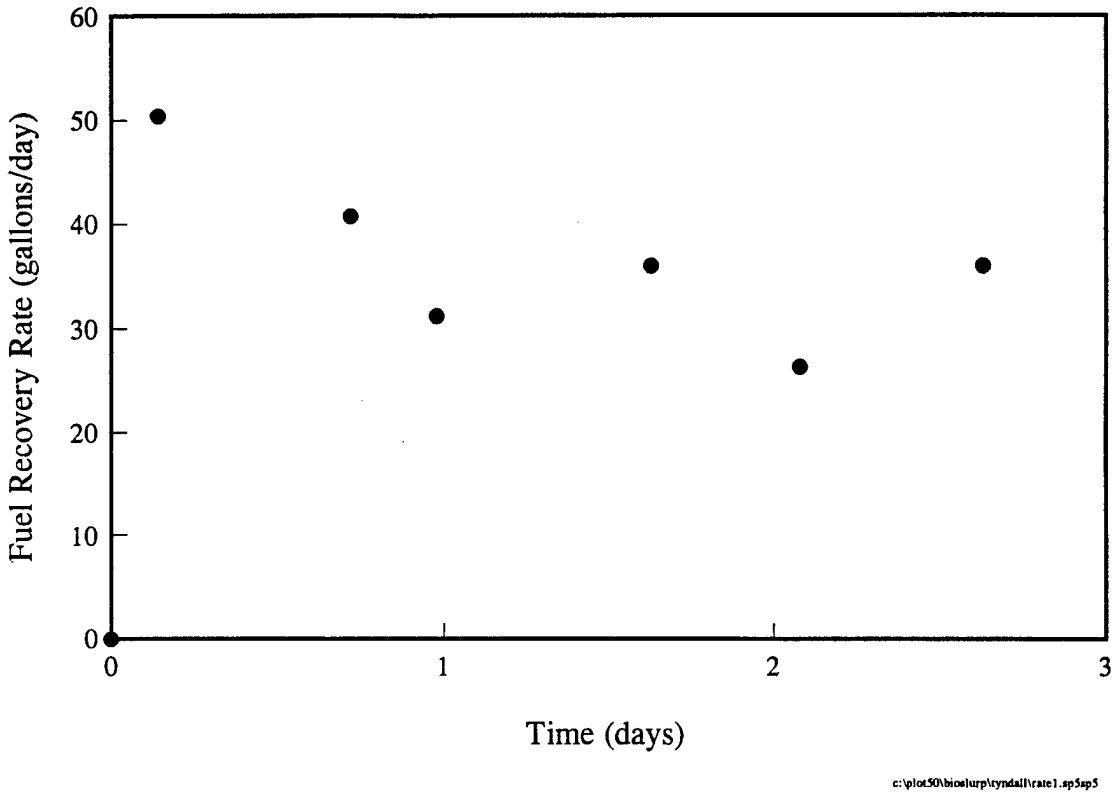

Figure 8. **Fuel Recovery Rate Versus Time During the Bioslurper Pump Test in Extraction Wells EW-1 and EW-2**

Table 9. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at Site SS-15, Tyndall AFB, FL**

Parameter	Concentration (mg/L)		
	TYN-DW-1	TYN-DW-2	TYN-DW-3
TPH	7.4	15	100
Benzene	0.21	0.022	3.8
Toluene	0.38	0.049	3.2
Ethylbenzene	0.15	0.034	1.3
Total Xylenes	1.0	0.21	7.2

Table 10. **BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at Tyndall AFB, FL**

Parameter	Concentration (ppmv)		
	TYN-OGS-1	TYN-OGS-2	TYN-OGS-3
TPH as jet fuel	3,600	28,000	0.89
Benzene	31	110	<0.04
Toluene	17	240	<0.04
Ethylbenzene	2.8	58	<0.04
Xylenes	12	240	<0.04

28,000 ppmv TPH and 110 ppmv benzene, approximately 65 lb/day of TPH and 0.19 lb/day benzene were emitted to the air.

The composition of LNAPL is shown in Tables 11 and 12 in terms of BTEX concentrations and distribution of C-range compounds, respectively. The distribution of C-range compounds is shown graphically in Figure 9.

4.4 Bioventing Analyses

4.4.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. Based on this definition, the radius of influence during the bioslurper pump test at monitoring well MW-5 was approximately 60 ft (Figure 10).

4.4.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 13. Oxygen depletion was relatively rapid, with oxygen utilization rates ranging from 0.42 to 0.84 O_2/hr. Biodegradation rates ranged from 6.8 to 14 mg/kg-day. The helium concentration was steady, indicating that leakage and diffusion were insignificant.

5.0 DISCUSSION

Less than 5 gallons of LNAPL were recovered during the series of pump tests at monitoring well MW-5. Groundwater was extracted at relatively high rates, ranging from 287 gallons/day during the initial skimmer pump test up to 2,207 gallons/day during the initial drawdown pump test.

During the bioslurper pump test conducted at EW-1 and EW-2, free product recovery rates remained relatively stable at approximately 36 gallons/day. Groundwater recovery rates also remained relatively stable at approximately 1,600 gallons/day. These results demonstrated there was

Table 11. BTEX Concentrations in LNAPL from Tyndall AFB, FL

Compound	Concentrations (mg/kg)
Benzene	1,800
Toluene	6,000
Ethylbenzene	2,700
Total Xylenes	17,000

Table 12. C-Range Compounds in LNAPL from Site FT-23, Tyndall AFB, FL

C-Range Compounds	Percentage of Total
<C7	32.96
C8	9.22
C9	10.84
C10	10.90
C11	11.70
C12	10.06
C13	7.40
C14	3.91
>C15	3.01

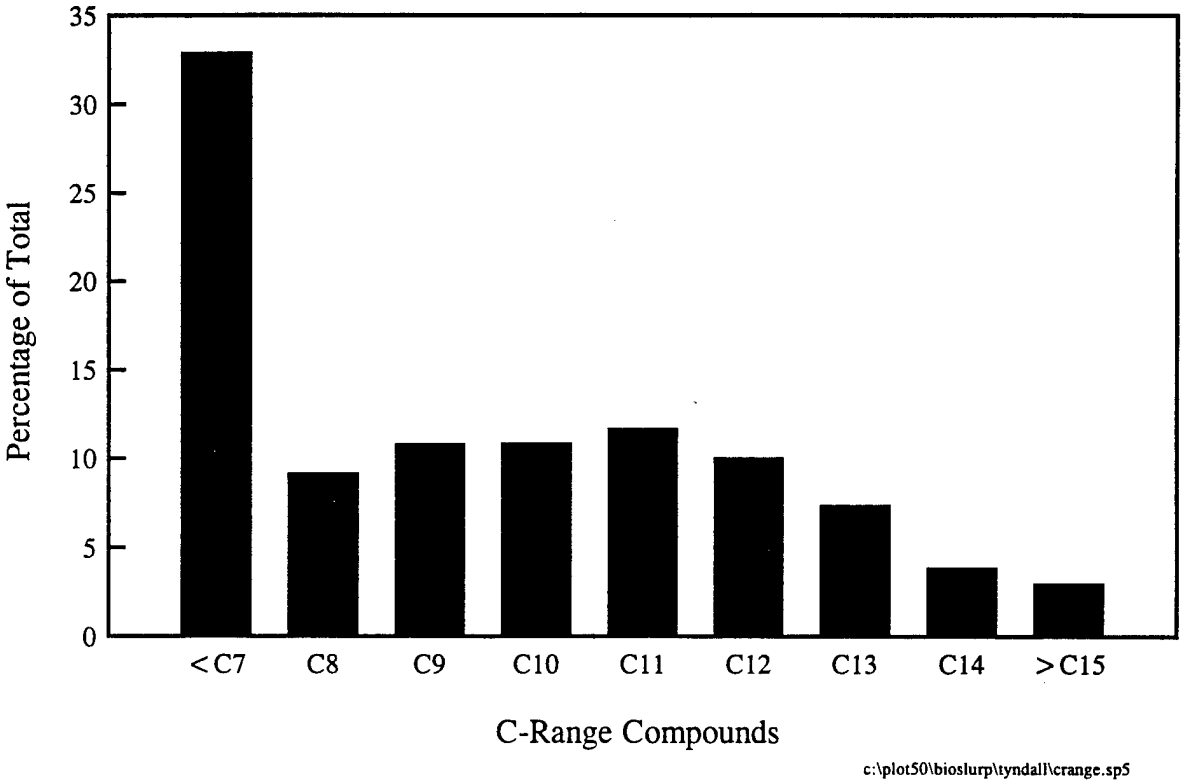

Figure 9. **Distribution of C-Range Compounds in Extracted LNAPL at Site FT-23, Tyndall AFB, FL**

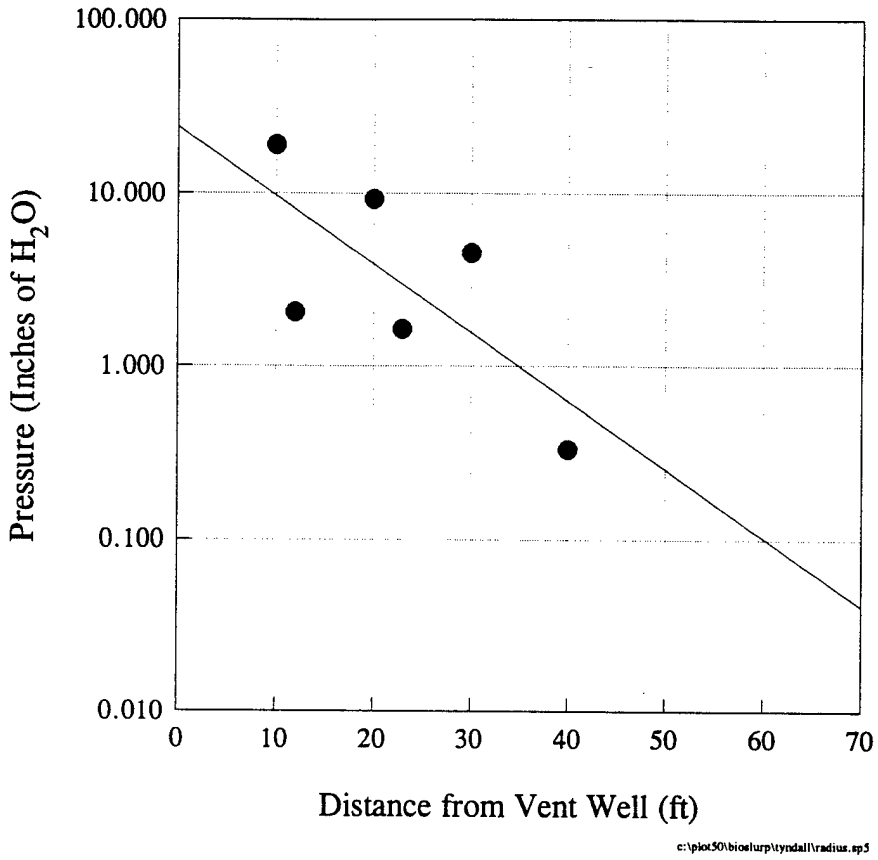

Figure 10. **Soil Gas Pressure Change as a Function of Distance During the Soil Gas Permeability Test at Monitoring Well MW-5**

Table 13. In Situ Respiration Test Results at Site FT-23, Tyndall AFB, FL

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
MPA-3.5′	0.84	14
MPB-3.5′	0.69	11
MPD-3.5′	0.59	9.6
MPE-3.5′	0.42	6.8

significantly greater free product recovery at monitoring wells EW-1 and EW-2 than at monitoring well MW-5. This difference could be accounted for by differences in well construction or simply differences in geology that affect free product mobility.

Based on the results at monitoring wells EW-1 and EW-2, implementation of bioslurping at Site FT-23 may facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing.

6.0 REFERENCES

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping*, Report prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT TYNDALL AFB, FLORIDA

SITE-SPECIFIC TEST PALN FOR BIOSLURPER TESTING AT TYNDALL AIR FORCE BASE, FLORIDA CONTRACT NO. F41624-94-C-8012

DRAFT

to

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May 3, 1995

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SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT TYNDALL AIR FORCE BASE, FLORIDA

DRAFT

U.S. Air Force
Brooks AFB

May 3, 1994

1.0 INTRODUCTION

The Air Force Center for Environmental Excellence is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technology tested in the Bioslurper Initiative is vacuum-mediated free-product recovery/bioremediation (bioslurping). The field test and evaluation are intended to demonstrate the initial feasibility of bioslurping by measuring system performance in the field. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geologic conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is the overall test plan and technical protocol for the entire program, entitled *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). The overall plan is supplemented by plans specific to each test site. This letter report is the site-specific supplement for Tyndall Air Force Base, Florida.

The overall test plan and protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of test plan preparation. The field program requires installation and operation of the bioslurping system is supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall plan allows efficient documentation and review of the basic approach to the test program.

Details required for application at each site are covered by individual supplements for that site. Site-specific plans effectively communicate regulatory background to Base personnel. This letter report was prepared based on site-specific information received by Battelle from Tyndall AFB and other pertinent site-specific information to support the generic test plan.

Site-specific information for Tyndall AFB included data for the active fire training area, Site FT-23. The FT-23 site is located at the east side of the flight line at Tyndall AFB. An initial review of the data indicates that the fire training site, specifically Well No. MW-5, appears to be the best candidate for the bioslurper pilot test.

2.0 SITE DESCRIPTION

The information in the Site Description portion of this test plan was obtained from the document titled, *Free-Phase Hydrocarbon Delineation and Soil Quality Investigation, Fire Training Area 23, Tyndall Air Force Base* (Prepared for the U.S. Air Force, Tyndall Air Force Base, Florida). This document is referenced as FPHD (1994) in the test plan text.

The Fire Training Area 23 (FT-23) site is located at the east side of the flight line at Tyndall AFB. Petroleum is stored at the site in a 10,000-gallon nominal capacity steel aboveground storage tank (AST). The AST is housed on a concrete pad, and is surrounded by a 3-foot-high concrete containment system. The fill port to the AST is located at the southwest corner of the AST containment system. Figure 1 depicts the FT-23 site and the monitoring wells that are installed within the area. Figure 1 also contains the soil boring points and push well points where soil and water samples were collected. There are two perceived locations of free-phase hydrocarbons contaminating the FT-23 site.

Figure 2 is a map which depicts the free-phase hydrocarbon plumes that are contaminating the subsurface soils and groundwater at the FT-23 site. During fire training, product is pumped from the AST through the pump house located adjacent to the west side of the AST in Figure 1. Product is directed to the fire training pit through an extensive underground distribution system. The fire training pit is located approximately 130 feet west of the pump house. This is also the approximate location of the free-phase hydrocarbon plume contaminating the area.

The presence of LNAPL resulted in site surveys of the area by Geraghty and Miller and OHM Remediation Services. Measurements of free product thicknesses in the FT-23 site wells are presented in Table 1. During these surveys, site geologic characteristics, groundwater movement, and extent of subsurface contamination were investigated.

2.1 Site Geology

The soil at the FT-23 site consists of brown, black, and white, angular to subangular, fine-grained silty sands. An abundance of organic material was observed in the soils. Soil borings were initially completed along the potential sources of contamination, including the distribution system piping, the pump house, the AST, and the fire training pit area. Upon confirmation of petroleum-affected soils, additional soil borings were completed radially away from the potential sources. The borings were drilled until the extent of affected soils had been adequately delineated. The affected soils extend approximately 75 feet north and south of the fuel distribution system piping.

2.2 Aquifer Characteristics

Groundwater was encountered at depths ranging from 1 to 4 feet below sea level. The groundwater samples that were collected during the FPHD (1994) study came from the temporary push wells installed that did not exhibit free-phase hydrocarbons. The hydraulic conductivity and hydraulic gradient of the FT-23 site also were determined during the 1994 study. The Little Cedar Bayou, located to the south of FT-23, controls the local hydraulic gradient. The direction of the hydraulic gradient was determined to be generally toward the south at a magnitude of 0.0264 ft/ft. To determine the hydraulic conductivity of the shallow aquifer, slug tests were performed in four existing monitoring wells (FT23-MW-1, TY22FTA, T11-3, and T11-1). The results from the slug tests are presented in Appendix B. During previous site characterization tests (FPHD, 1994), the hydraulic conductivity was found to range from 0.348 ft/day in well #T11-3 to 1.781 ft/day in well #TY22FTA. The groundwater velocity was determined to range from 0.03 ft/day to 0.112 ft/day, and the direction of flow is to the south.

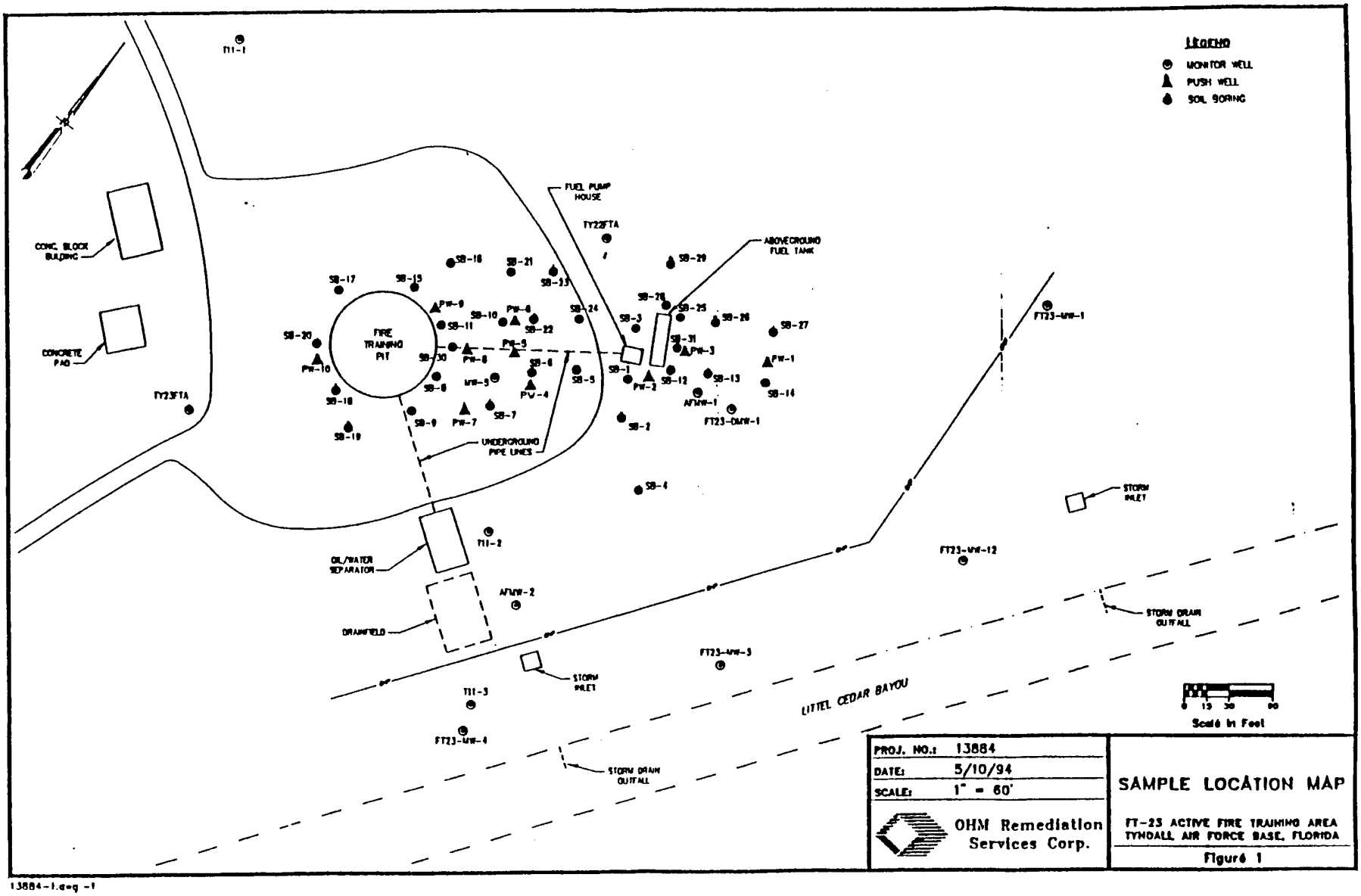


Figure 1. Location of the Area of Interest for Bioslurper Testing at Tyndall AFB.

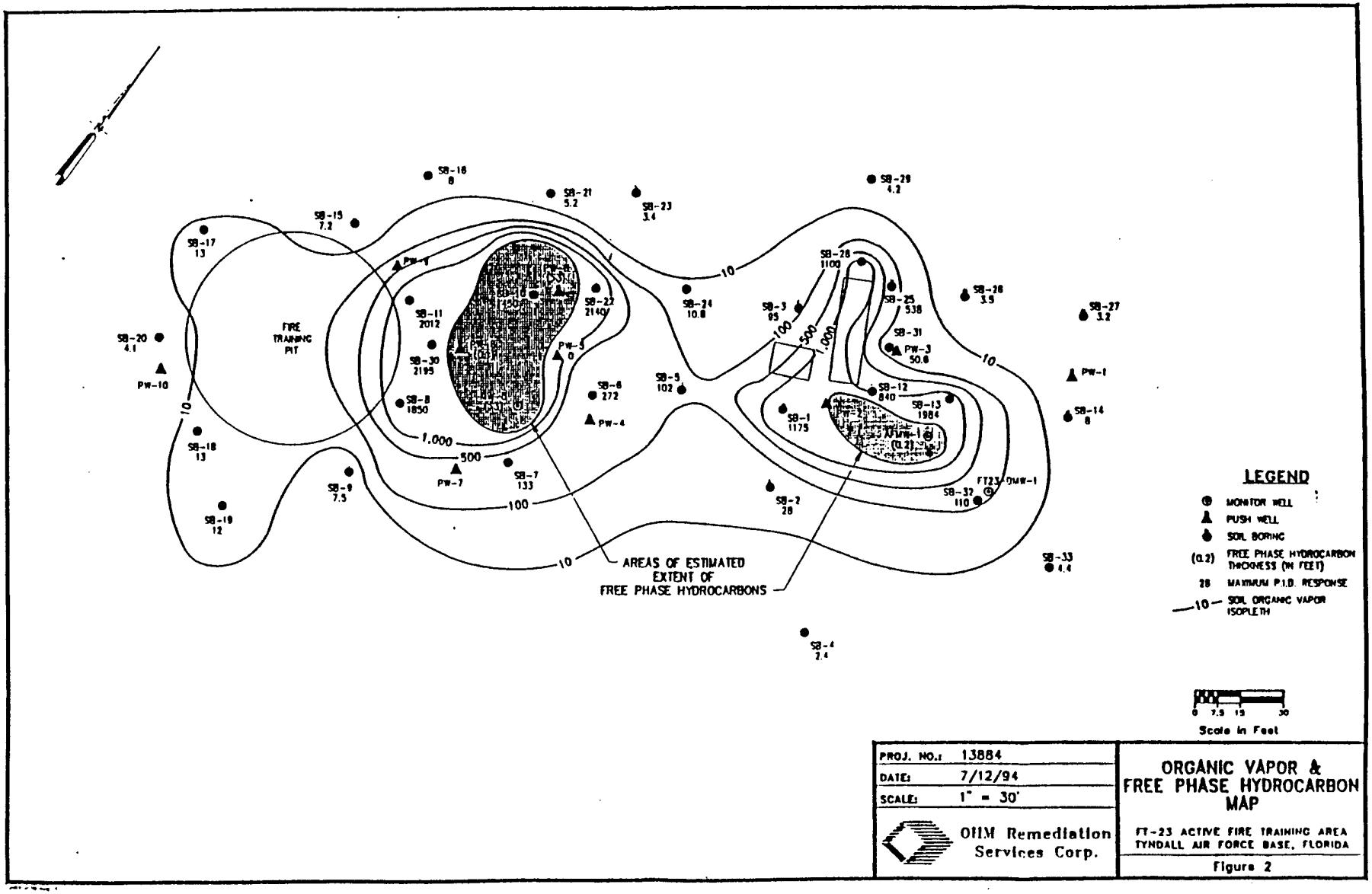


Figure 2. Location of Site Monitoring Wells in Fire Training Area 23 at Tyndall AFB.

2.3 Site Contamination

The organic liquid contaminant at the FT-23 site as stated previously is JP-4 jet fuel. Results from the soil sample data collected during the FPHD (1994) study are presented in Table 2. The results show that concentrations of benzene in the soils range from 0.06 to 8.7 mg/kg, and the concentrations of total petroleum hydrocarbons (TPH) range from 10 to 960 mg/kg. Results from the water samples collected during the study are presented in Table 3. The results from the water samples show that benzene is present in concentrations that range from 0.01 to 0.58 mg/L, and TPH in concentrations that range from 0.26 to 5.47 mg/L. As can be seen from Figure 2, there are two principal areas of contamination at the FT-23 site. The eastern plume is centered at the south side of the pump house and encompasses the AST and the pump house. The second and larger plume of free-phase hydrocarbons is located to the west of the pump house and was observed along the distribution piping east and extending under the fire training pit. Most likely, FT23-MW-5 will be used as the bioslurper extraction well. This well has exhibited the largest measured thicknesses of free-phase hydrocarbons during the past year.

Table 1. Site Investigation — FT-23 Area at Tyndall Air Force Base, Florida, on 6/19/93

Monitoring Well Number	Depth to Product (ft bTOC)	Depth to Water (ft bTOC)	Product Thickness (ft)	Groundwater Elevation (ft amsl)
FT23-MW-1	—	4.68	—	4.71
FT23-MW-2	—	4.60	—	3.49
FT23-MW-3	—	7.90	—	1.98
FT23-MW-4	—	9.35	—	1.75
FT23-MW-5	N/A	N/A	3.0	—
FT23-DMW-1	—	20.70	—	-9.11

bTOC = below top of casing
amsl = above mean sea level
N/A = not available

Table 2. Soil Quality Results from FPHD (1994) Study by OHM Remediation Services

Sample ID	SB30 (mg/kg)	SB31 (mg/kg)
Benzene	0.435	nd
Toluene	1.630	nd
Ethylbenzene	2.740	nd
Xylene	22.340	nd
TPH	0.960	nd

nd = not detected

Table 3. Groundwater Quality Results from FPHD (1994) Study by OHM Remediation Services

Sample ID	PW 1 (ug/L)	PW 2 (ug/L)	PW 4 (ug/L)	PW 5 (ug/L)	PW 7 (ug/L)	PW 9 (ug/L)	PW 10 (ug/L)
Benzene	5.5	4,000	3,200	4,160	21.5	2,200	2.2
Toluene	1.8	2,220	nd	5,940	31.2	nd	nd
Ethylbenzene	16.3	670	175	960	8.2	165	nd
Xylene	337	4,090	529	6,160	76.4	115	nd

nd = not detected

3.0 PROJECT ACTIVITIES

The following field activities are planned for the bioslurper pilot test at Tyndall AFB. Additional details about the activities are presented in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). As appropriate, specific sections in the generic Bioslurping Protocol assessment are referened. Table 4 shows the schedule of activities for the Bioslurper Initiative at Tyndall AFB.

3.1 Mobilization to the Site

After the site-specific test plan has been approved, Battelle staff will mobilize equipment to the test site. All equipment will be brought to Tyndall AFB by Battelle staff. The Base Point of Contact (POC) will have been asked in advance to find a suitable holding facility to receive any previously shipped bioslurper pilot test equipment, so that the Battelle staff on site can easily set up the bioslurper pilot-test demonstration when they arrive. The exact mobilization date to the site will be confirmed with the Base POC as far in advance of fieldwork as possible. The Battelle POC will provide the Air Force POC with personal information for each Battelle employee who will be on site.

3.2 Site Characterization Tests

3.2.1 Baildown Tests

The baildown test is the primary test for selection of the bioslurper pilot test well. Baildown tests will be performed at wells that contain measurable thicknesses of light, nonaqueous-phase liquid (LNAPL) to estimate the LNAPL recovery potential at those particular wells. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper extraction well. Table 5 presents the volume of fuel that would be present in a 1-foot measured thickness for various size wells. Detailed procedures for the baildown tests are provided in Section 5.6 of the generic Bioslurping Protocol.

3.2.2 Soil-Gas Survey (Limited)

A small-scale soil-gas survey will be conducted to characterize surface soil gas conditions and to support selection of locations for permanent soil gas monitoring points. The soil-gas survey will be conducted in areas where historical site data indicate the highest contamination levels. The area around these site monitoring wells will be surveyed to select the best locations for installation of soil-gas monitoring points. Soil-gas monitoring point placement will be concentrated around areas that exhibit the following characteristics:

1. Soil vapor from the site will exhibit high TPH concentrations (10,000 ppm or greater).
2. Soil vapor will contain relatively low oxygen concentrations (between 0% and 2%).
3. Soil vapor will have relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

To obtain further information about the soil-gas survey, consult Section 5.2 of the generic Bioslurping Protocol.

Table 4. Schedule of Bioslurper Test Activities

Pilot Test Activity	Schedule
Test Plan Approval	day (to be determined)
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests	
Soil-Gas Survey (limited)	
Monitoring Point (MP) Installation (3 MPs)	
Soil Sampling	
System Installation	day 2-3
Test Startup	day 4
Skimmer Test (1 day)	day 4
Bioslurper Pump Test (4 days)	day 5-9
Air Permeability Testing	day 5
Drawdown Pump Test (1 day)	day 9
In Situ Respiration Test (air/helium injection)	day 9
In Situ Respiration Test (monitoring)	day 10-12
Demobilization/Mobilization	day 12-14

Table 5. Volumes per Unit Length for Common Well Casing Diameters

Nominal Pipe Size	Gal/ft (Schedule 40 Pipe)	Gal/ft (Schedule 80 Pipe)
2.0	0.174	0.153
3.0	0.384	0.343
4.0	0.661	0.597
6.0	1.50	1.35

3.2.3 Monitoring Point Installation

Monitoring points must be installed to determine the radius of influence that the free-product recovery system has on vadose zone contaminated soils. After the initial soil gas survey and baildown tests have been conducted, at least three soil gas monitoring points will be installed at the test site. These monitoring points should be located in highly contaminated soils within the free-phase plume, and should be positioned to allow detailed monitoring of the in situ changes in soil gas composition

caused by the bioslurper system. The components of a soil-gas monitoring point are shown in Figure 3. Information on monitoring point installation can be found in Section 4.2.1 of the generic Bioslurping Protocol.

3.2.4 Soil Sampling

Soil sampling will be conducted to identify soil and contaminant characteristics at the bioslurper pilot test site. Soil samples from the chosen site will be collected from boreholes advanced for monitoring point installation. Two soil samples will be collected at the proposed test site. Generally, samples will be collected from one borehole through the capillary fringe over the free product.

Soil samples will be analyzed for total phosphorous; total Kjeldahl nitrogen; pH; total iron; particle-size distribution; bulk density; porosity; moisture content; benzene, toluene, ethylbenzene, and xylenes (BTEX); and TPH. Section 5.5.1 of the generic Bioslurping Protocol will be consulted for information on the field measurements and sample collection procedures for soil sampling.

3.3 Bioslurper System Installation and Operation

Once the well for the bioslurper test installation at Tyndall AFB has been identified (most likely Well No. MW-5), the bioslurper pump (5 or 7 hp) and support equipment will be installed and the pilot test will be initiated.

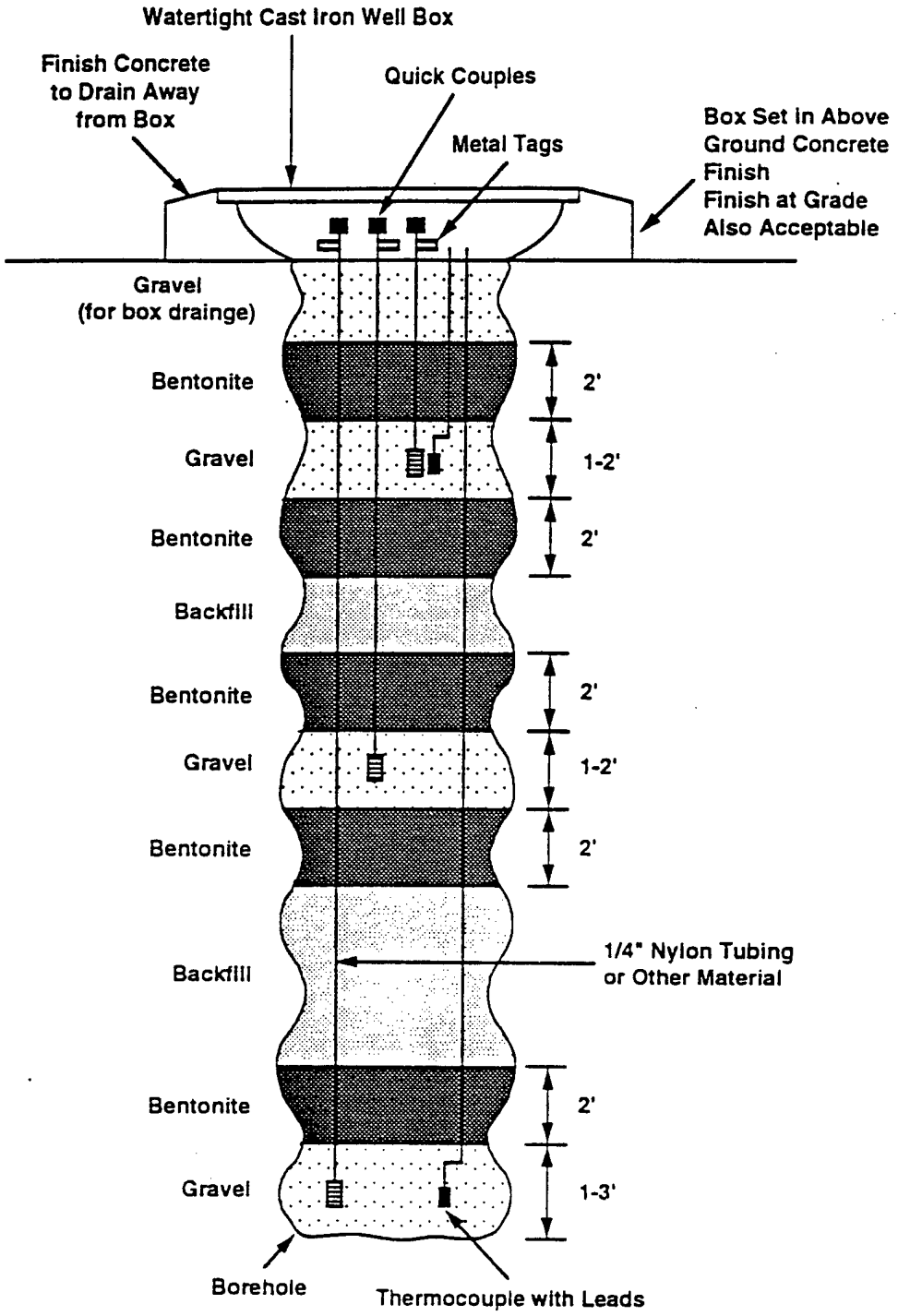


Figure 3. Diagram of a Typical Bioslurper Soil Gas Monitoring Point

3.3.1 System Setup

After the preliminary site characterization tests have been completed and the bioslurper candidate well has been identified, the bioslurper system will be assembled. Figure 4 shows a flow diagram of the bioslurper process. Figure 4 is a diagram of the monitoring well which is expected to be used for the pilot test.

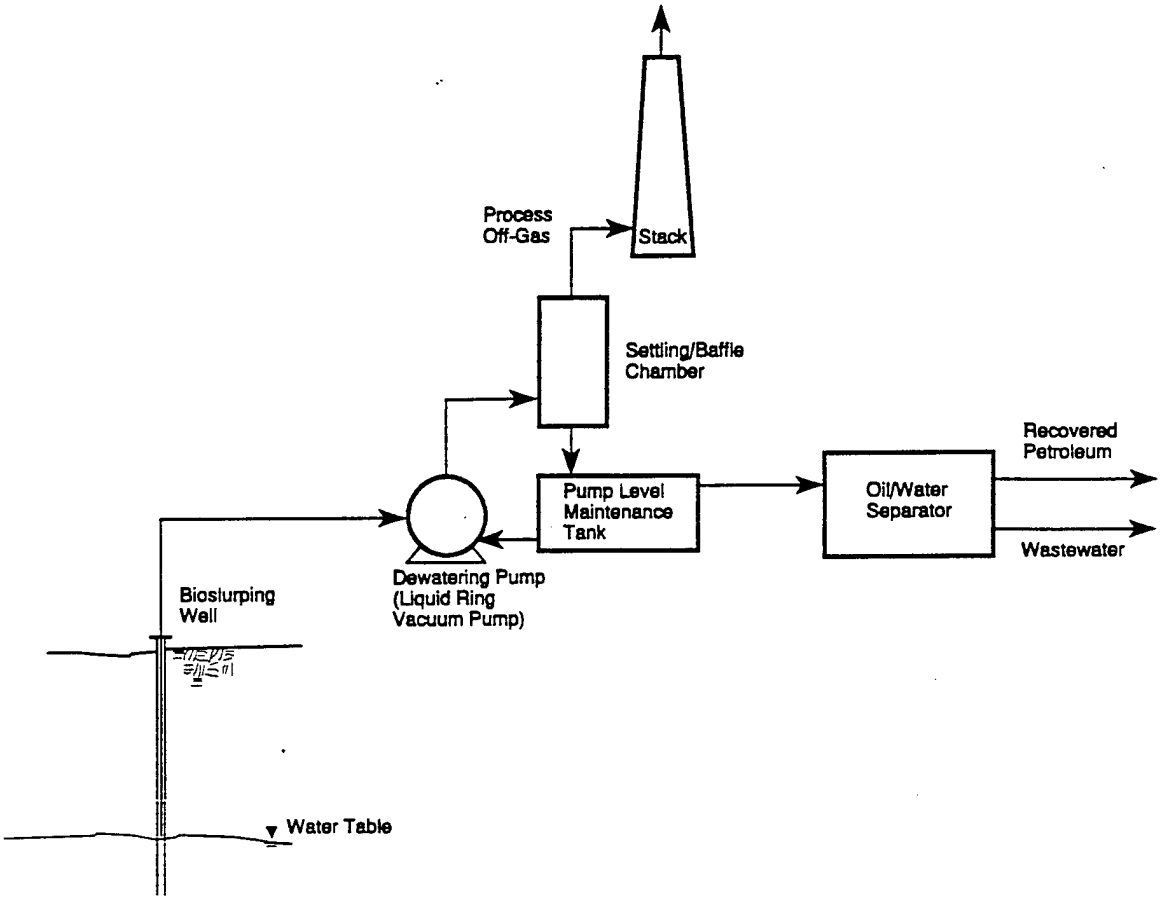


Figure 4. Bioslurper Process Flow.

Before the LNAPL recovery tests are initiated, all relevant baseline field data will be collected and recorded. These data will include soil-gas concentrations, initial soil-gas pressures, depth to groundwater, and LNAPL thickness. Ambient soil and all atmospheric conditions (i.e., weather conditions, temperature, humidity, and barometric pressure) also will be recorded. All emergency equipment (i.e., emergency shutoff switches and fire extinguishers) will be installed and checked for proper operation at this time.

Well No. MW-5 most likely will be used for the installation of the bioslurper extraction well. A cleared, level area near Well No. MW-5 must be identified for the 20-ft by 10-ft area that will be needed to house the flat-bed trailer that holds the equipment required for bioslurper system operation. For more information on the bioslurper system installation, consult Section 6.0 generic Bioslurping Protocol.

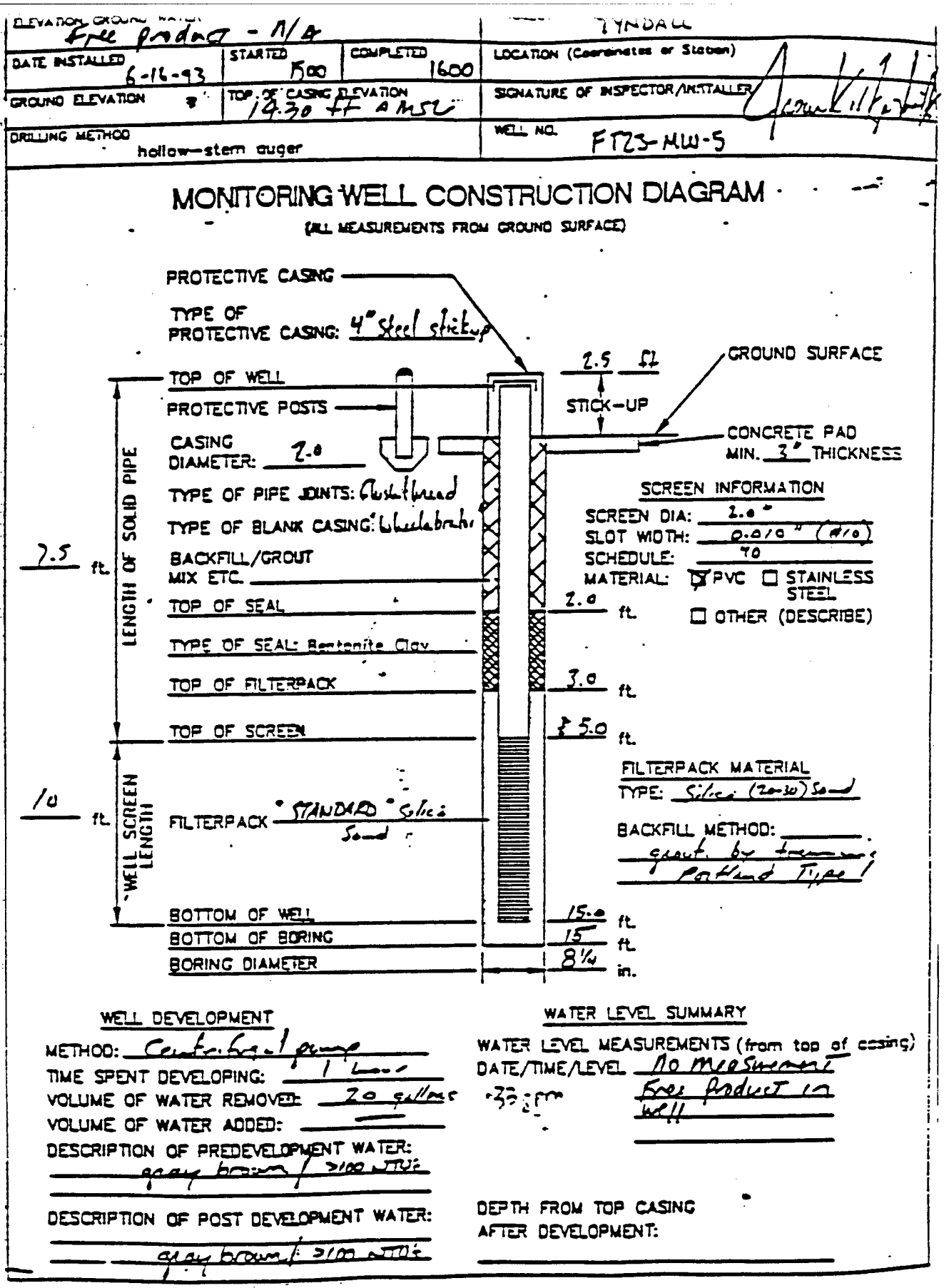


Figure 5. Diagram of Fire Training Area 23 – Monitoring Well #5 at Tyndall AFB.

3.3.2 System Shakedown

A brief startup test will be conducted to ensure that the system is properly constructed and operates safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

3.3.3 System Startup and Test Operations

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as a LNAPL recovery technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative includes three separate LNAPL recovery tests: (1) a skimmer simulation test, (2) a vacuum-assisted bioslurper test, and (3) a groundwater drawdown LNAPL recovery test. The three recovery tests are described in detail in Section 7.3 of the generic Bioslurping Protocol.

The bioslurper system operating parameters, that will be measured during operation are vapor discharge, aqueous effluent, LNAPL recovery volume rates, vapor discharge volume rates, and groundwater discharge volume rates. Vapor monitoring will consist of continuous on-line monitoring of TPH supplemented by two samples collected for detailed laboratory analysis. A total of two samples of aqueous effluent will be collected for analysis of BTEX and TPH content. Recovered LNAPL volume will be recorded using an in-line flow-totalizing meter. The off-gas discharge volume will be measured using a calibrated pitot tube, and the groundwater discharge volume will be recorded using an in-line flow-totalizing meter. Section 8.0 of the generic Bioslurping Protocol describes the process monitoring of the bioslurper system.

3.3.4 Soil-Gas Permeability Tests

A soil-gas permeability test will be conducted concurrently with startup of the vacuum-assisted bioslurper operation. Soil-gas permeability data support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil-gas permeability results also aid in determining the number of wells required if it is decided to treat the site with a large-scale bioslurper system. The soil-gas permeability test method is described in Section 5.8 of the draft generic Bioslurping Protocol.

3.3.5 In Situ Respiration Tests

The oxygen utilization rate will be used to estimate the biodegradation rate for the site. An in situ respiration test will be conducted after completion of the bioslurper operating tests. The in situ respiration testing will consist of air/helium injection into selected soil-gas monitoring points followed by monitoring changes in concentrations of oxygen, carbon dioxide, petroleum hydrocarbons, and helium in soil-gas near the injection point. Measurement of the soil-gas composition typically will be conducted at 2, 4, 6, and 8 hours, and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on oxygen-use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be required. If oxygen depletion is slow, less frequent readings will be acceptable. Further information on the procedures and data collection for in situ respiration testing is given in Section 5.8 of the generic Bioslurping Protocol.

3.3.6 Extended Testing

The Air Force has the option of extending the operation of the bioslurper system for up to 6 months if LNAPL recovery rates are promising. If extended testing is to be performed, the Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

3.4 Demobilization

Once all the necessary tests have been completed at the Tyndall AFB site, the equipment will be disassembled by Battelle staff. The equipment then will be moved back to the holding facility, where it will remain until its next destination is determined. Battelle staff will receive this information and will be responsible for shipment of the equipment to the next site before they leave Tyndall AFB.

4.0 BIOSLURPER SYSTEM DISCHARGE

4.1 Vapor Discharge Disposition

It is Battelle's understanding that the operation of the bioslurper test system at the Tyndall AFB site will not require a waiver or a point source air release registration or permit. Stack emission levels should be less than 60 lb TPH/day during the short-term biosluper pilot test. The organic vapor discharge concentrations estimated in Table 6 are based on stack gas emissions data collected during previous bioslurping studies performed at the various sites during the past year. Due to the short duration of the test, the organic vapor discharge rate should remain relatively constant throughout the pilot test at Tyndall AFB and is estimated to be less than 65 lb/day. This discharge rate is based on the previous short-term pilot test data for similar test sites shown in Table 6. Depending upon the State of Florida's vapor discharge regulations, the vapor stream generated by the bioslurper system can be discharged directly to the atmosphere because of the short duration of the test and the low concentration levels of TPH and benzene in the stream.

Table 6. Benzene and TPH Discharge Levels at Previous Bioslurper Test Sites

Site Location	Fuel Type	Extraction Rate (scfm)	Benzene (ppmv)	TPH (ppmv)	Benzene Discharge (lb/day)	TPH Discharge (lb/day)
Wright-Patterson AFB	Jet Fuel	3	ND	595	0.0	1.0
Bolling AFB (Site #1)	No.2 Fuel Oil	4	0.2	153	0.0003	0.009
Bolling AFB (Site #2)	Gasoline	21	370	70,000	2.3	470.1
Travis AFB	Jet Fuel	20	100	10,800	0.58	126.4
Andrews AFB	No. 2 Fuel Oil	8	16	2,000	0.001	0.2

To ensure the safety and regulatory compliance of the bioslurper system, vapor discharge samples (TPH, O_2, and CO_2) will be collected periodically throughout the bioslurper pilot test. Also, field soil-gas screening instruments will be used to monitor vapor discharge concentration variability. The volume of vapor discharge will be monitored daily using air flow instruments. If state regulatory requirements will not permit the expected amount of organic vapor discharge to the atmosphere, the Base POC should inform AFCEE and Battelle so that alternative plans can be made prior to mobilization to the site. Table 7 presents information typically required to complete an air release registration form.

4.2 Aqueous Influent/Effluent Disposition

The flowrate of groundwater pumped by the bioslurper is expected to be less than 5 gpm. However, it may be necessary in Florida to obtain a groundwater pumping waiver or registration permit. If one is required, the Tyndall Base POC will inform Battelle of the necessary steps in obtaining the waiver or permit.

Operation of the bioslurper system will generate an aqueous waste discharge that will be passed through an oil/water separator. The flowrate of the wastestream is expected to be less than 5 gpm. The intention of Battelle staff at Tyndall AFB will be dispose of the generated wastewater by discharge directly to the Base sanitary sewer. If existing Base wastewater channels can be used, no National Pollutant Discharge Elimination System (NPDES) or other water discharge permits will be required.

Table 7. Air Release Summary Information

Data Item	Air Release Information
Contractor Point of Contact	Jeff Kittel, (614) 424-6122
Contractor address	Battelle 505 King Avenue Columbus, Ohio 43201-2693
Estimated total quantity of petroleum product to be recovered	TBD
Description of petroleum product to be recovered	JP-4 jet fuel
Planned date of test start	April 30, 1995
Test duration	9 days (active pumping)
Maximum expected VOC concentration in air	<65 lb/day (<60 lb TPH/day, <1 lb benzene/day)
Maximum total quantity of VOC release	<65 lb/day
Expected contaminants in air release	TPH, benzene
Expected quantity of fuel use (for electrical generator)	125 gal
Type of fuel used	Gasoline and diesel fuel
Stack height above ground level	10 ft

4.3 Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at Tyndall AFB. Free product recovered by the bioslurping tests will be turned over to the Base for disposal and/or recycling. The volume of free product recovered from the Base will not be known until the tests have been performed. The maximum recovery rate for this system is expected to be 5 gpm. However, the actual rate of LNAPL recovery will be much lower.

5.0 SCHEDULE

The schedule for the bioslurper fieldwork at Tyndall AFB will depend on approval of the project test plans. Battelle will determine a definitive schedule as soon as possible after approval. Battelle will have two to three staff members on site for approximately 2 weeks to conduct all the necessary pilot testing. At the conclusion of the field testing at Tyndall AFB, all staff will return their Base passes. Battelle staff will remove all bioslurper field testing equipment from the Base before they leave the site.

6.0 PROJECT SUPPORT ROLES

This section outlines the some of the major functions of personnel from Battelle, Tyndall AFB, and AFCEE during the bioslurper field test.

6.1 Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Tyndall AFB will be to supply all the staff and equipment necessary to perform all the tests on the bioslurper system. Battelle also will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed.

6.2 Tyndall AFB Support Activities

To conduct the necessary field tests at Tyndall AFB, the Base must be able to provide the following items:

1. Any and all digging permits and utility clearances that need to be obtained prior to the initiation of the fieldwork. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil gas probe and possible well installation. Battelle will not begin field operations without these clearances and permits.

2. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all necessary information or each staff member at least 1 week prior to field startup.

3. Access to the local sanitary sewer must be furnished so that the Battelle staff on site can directly discharge the bioslurper aqueous effluent directly to the Base treatment facility.

4. Regulatory approval, if required, must be obtained by the Base POC prior to startup of the bioslurper test. As stated previously, it is likely that a waiver to allow air releases or a point source air release registration will be required for emissions of less than 65 lb/day of VOC. A waiver for pumping and discharging groundwater at a rate of 5 gpm might also be required. The Base POC will obtain all necessary permits prior to Battelle's mobilization to the site. Battelle will provide technical assistance in preparing regulatory approval documents.

5. The Base also will be responsible for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling, and all aqueous wastestreams produced from the bioslurper tests. All free product recovered from the bioslurper operation will be disposed of or recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

6. Before field activities begin, the Health and Safety Plan for Tyndall AFB will be finalized with information provided by the Base POC. Figure 6 is a checklist for the necessary information required to complete the Health and Safety Plan. All emergency information will be obtained by the Site Health and Safety Office before operation begins.

6.3 AFCEE Activities

The Air Force Center for Environmental Excellence (AFCEE) POC will serve as a liaison between Battelle and Tyndall Base staff. The AFCEE POC will ensure that all necessary permits are obtained and the required space to house the bioslurper field equipment is found.

The following is a listing of Battelle, AFCEE, and Tyndall Base staff that can be contacted in cases of emergency and/or required technical support during the bioslurper field initiative tests at Tyndall AFB:

Battelle POCs	—	Jeff Kittel	614-424-6122
		Eric Drescher	614-424-3088
AFCEE POC	—	Patrick Haas	210-536-4331
Tyndall AFB POC	—	Ed Carver	904-523-4354
Facility POCs		Active Fire Training Area 23	

References

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping.* Report to U.S. Air Force, Brooks AFB, TX. January.

FPHD, 1994. OHM Remediation Service Corp. 1994. *Free-Phase Hydrocarbon Delineation and Soil Quality Invesitgation, Fire Training Area 23.* Report to Tyndall AFB, Florida. August.

The following emergency information will be obtained by the Site Health and Safety Officer prior to beginning operations:

Emergency Contacts	Name	Telephone No.
Hospital Emergency Room:	_____	_____
Point of Contact:	_____	_____
Fire Department:	_____	_____
Emergency Unit (Ambulance):	_____	_____
Security:	_____	_____
Explosives Unit:	_____	_____
Community Emergency Response Coordinator:	_____	_____
Other:	_____	_____

Program Contacts

Air Force:_____

Battelle:_____

Other:_____

Emergency Routes

Hospital (maps attached): _____
Other:_____

Figure 6. Health and Safety Information Checklist

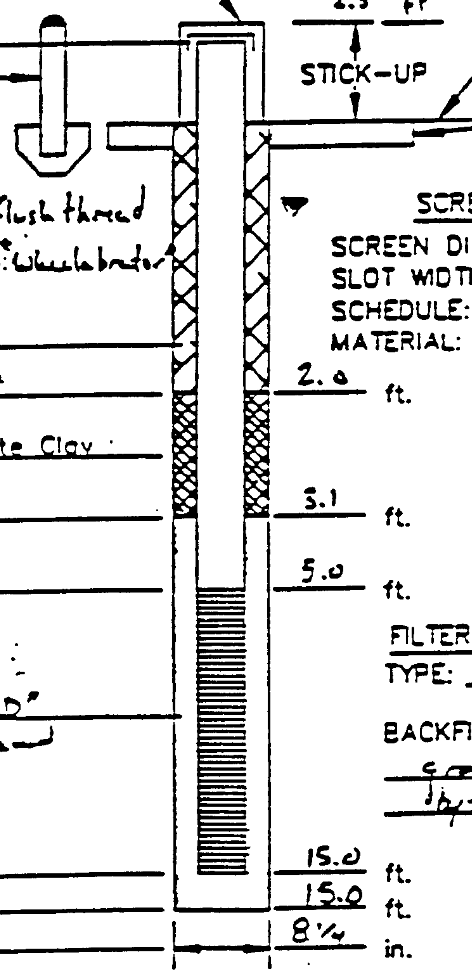
Appendix A

Well Boring Logs

ELEVATION GROUND WATER 4.71 ft ~~btc~~ AMSL	PROJECT: TYNDALL AFB
DATE INSTALLED 6-16-93 / STARTED 0800 / COMPLETED 0900	LOCATION (Coordinates or Station)
GROUND ELEVATION / TOP OF CASING ELEVATION 9.39 ft AMSL	SIGNATURE OF INSPECTOR/INSTALLER [signature]
DRILLING METHOD hollow-stem auger	WELL NO. FT23-MW-1

MONITORING WELL CONSTRUCTION DIAGRAM

(ALL MEASUREMENTS FROM GROUND SURFACE)



PROTECTIVE CASING

TYPE OF PROTECTIVE CASING: 4" steel stickup

GROUND SURFACE

TOP OF WELL — STICK-UP 2.5 ft

PROTECTIVE POSTS

CONCRETE PAD MIN. 3" THICKNESS

CASING DIAMETER: 2.0

TYPE OF PIPE JOINTS: flush thread

TYPE OF BLANK CASING: Wheelabrator

LENGTH OF SOLID PIPE 7.5 ft.

BACKFILL/GROUT MIX ETC.

TOP OF SEAL 2.0 ft.

TYPE OF SEAL: Bentonite Clay

TOP OF FILTERPACK 3.1 ft.

TOP OF SCREEN 5.0 ft.

WELL SCREEN LENGTH 10 ft.

FILTERPACK "STANDARD" Silica Sand

BOTTOM OF WELL 15.0 ft.

BOTTOM OF BORING 15.0 ft.

BORING DIAMETER 8¼ in.

SCREEN INFORMATION

SCREEN DIA: 2.0"

SLOT WIDTH: 0.010 (#10)

SCHEDULE: 40

MATERIAL: ☒ PVC ☐ STAINLESS STEEL ☐ OTHER (DESCRIBE)

FILTERPACK MATERIAL

TYPE: 20-30 Silica Sand

BACKFILL METHOD: grout/ Portland Type I bentonite

WELL DEVELOPMENT

METHOD: Centrifugal pump

TIME SPENT DEVELOPING: 1.5 hours

VOLUME OF WATER REMOVED: 110 gal.

VOLUME OF WATER ADDED: —

DESCRIPTION OF PREDEVELOPMENT WATER: gray brown / >100 NTUs

DESCRIPTION OF POST DEVELOPMENT WATER: gray brown / >100 NTUs

WATER LEVEL SUMMARY

WATER LEVEL MEASUREMENTS (from top of casing)

DATE/TIME/LEVEL

1:20 pm 4.68 6/19/93

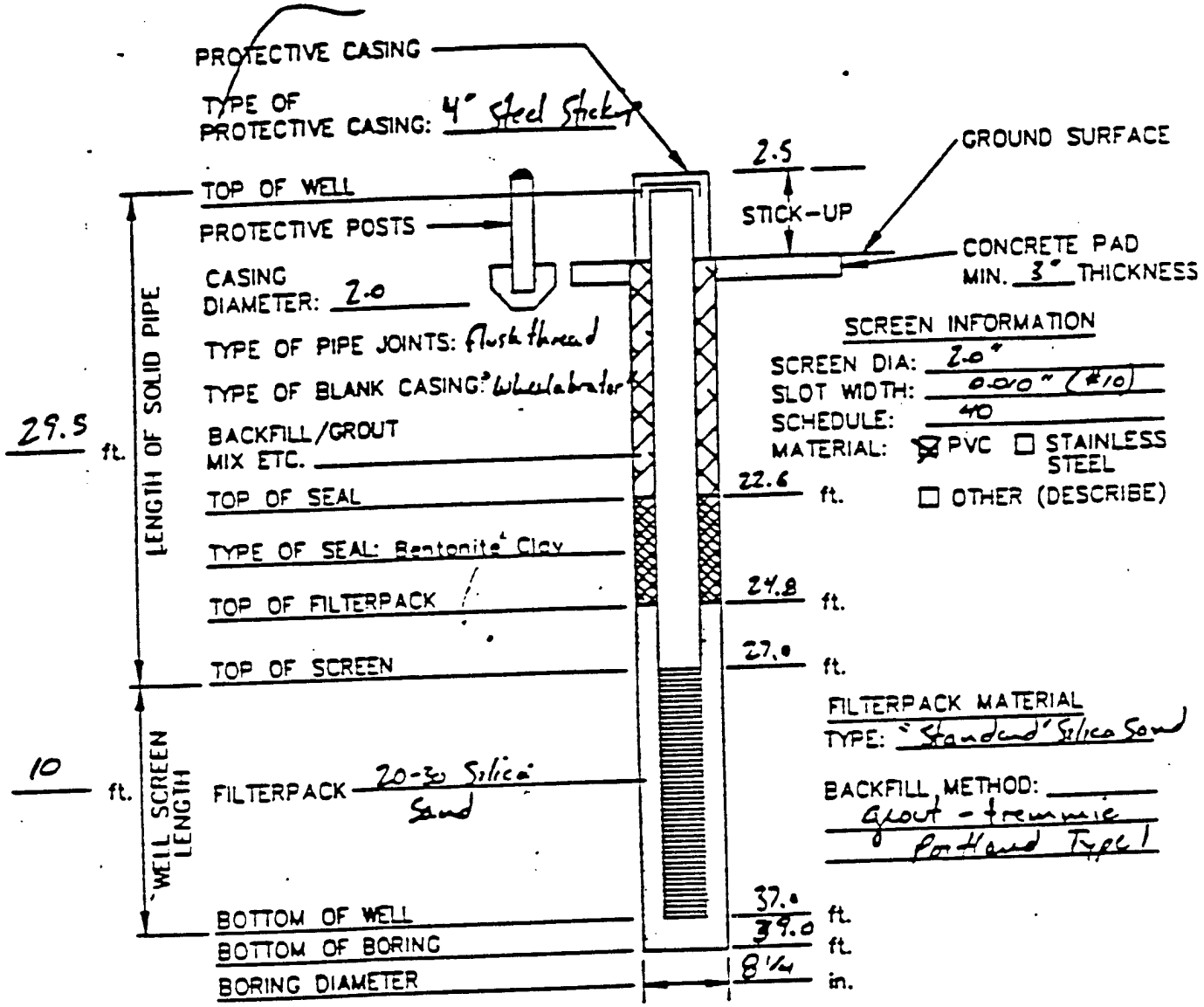
DEPTH FROM TOP CASING AFTER DEVELOPMENT:

Readings stable

DATE INSTALLED 6-17-93	0800 / 1600	
GROUND ELEVATION	TOP OF CASING ELEVATION 11.59 ft. amsl	SIGNATURE OF INSPECTOR/INSTALLER
DRILLING METHOD hollow-stem auger		WELL NO. FT23-DMW-4

MONITORING WELL CONSTRUCTION DIAGRAM

(ALL MEASUREMENTS FROM GROUND SURFACE)



WELL DEVELOPMENT

METHOD: Centrifugal Pump
TIME SPENT DEVELOPING: 1 hour
VOLUME OF WATER REMOVED: 15 gallons
VOLUME OF WATER ADDED:
DESCRIPTION OF PREDEVELOPMENT WATER: light brown / >100 NTUs
DESCRIPTION OF POST DEVELOPMENT WATER: light brown / >100 NTUs

WATER LEVEL SUMMARY

WATER LEVEL MEASUREMENTS (from top of casing)

DATE/TIME/LEVEL		
	20.70	
	6/19/93	
.25 pm		

DEPTH FROM TOP CASING AFTER DEVELOPMENT:

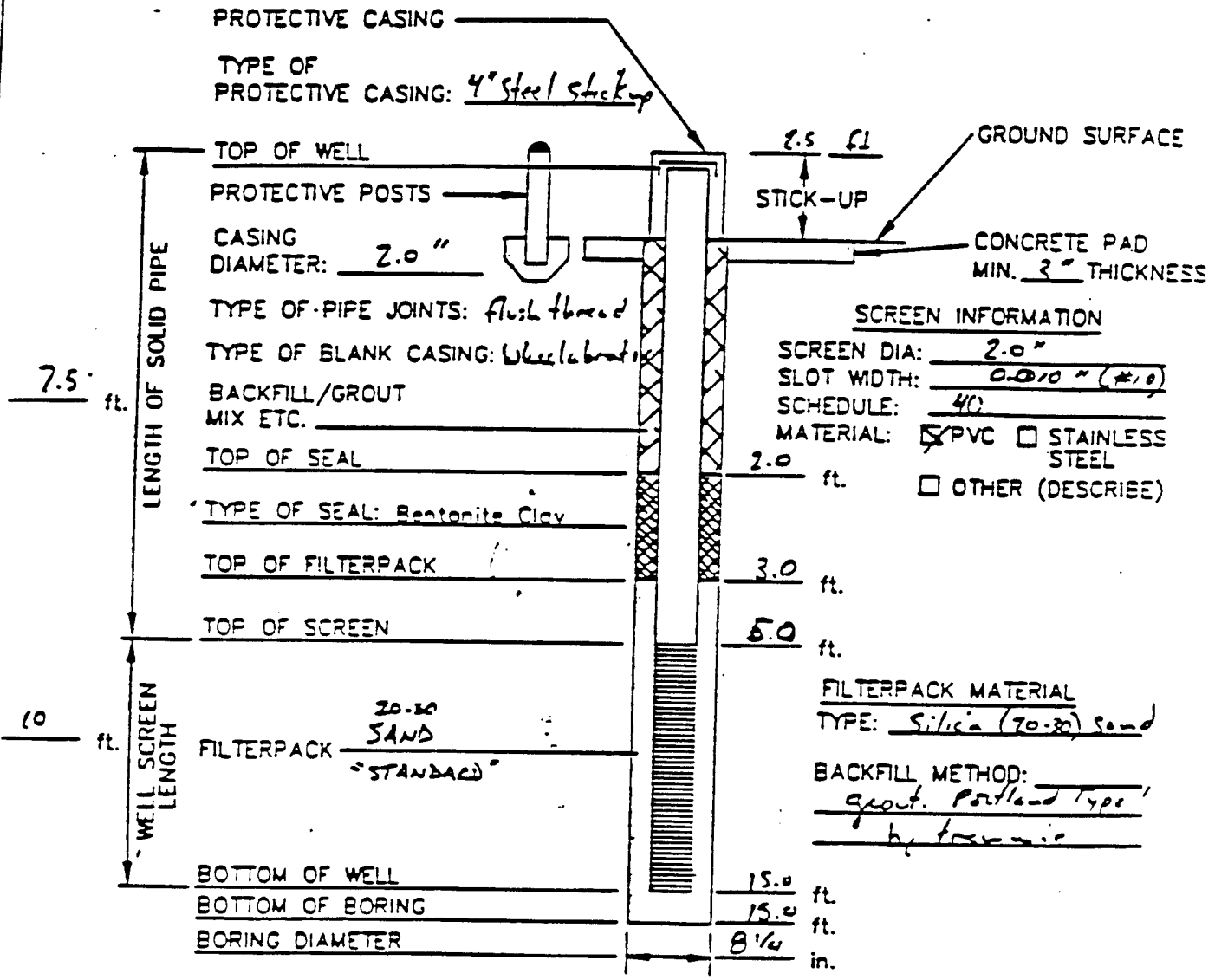
Stable readings.

M-01-03 / 1 HEAD / 1 ROW WELL DWG / SCALE: 1-1 / DAN I

DATE INSTALLED: 6-16-93	STARTED: 0945	COMPLETED: 1030	LOCATION (Coordinates or Station): TYNDALL
GROUND ELEVATION	TOP OF CASING ELEVATION: 8.09 ft AMSL		SIGNATURE OF INSPECTOR/INSTALLER: Jason Killingsworth
DRILLING METHOD: hollow-stem auger			WELL NO.: FT23-MW-2

MONITORING WELL CONSTRUCTION DIAGRAM

(ALL MEASUREMENTS FROM GROUND SURFACE)



SCREEN INFORMATION
- SCREEN DIA: 2.0"
- SLOT WIDTH: 0.010" (#10)
- SCHEDULE: 40
- MATERIAL: ☒ PVC ☐ STAINLESS STEEL ☐ OTHER (DESCRIBE)

FILTERPACK MATERIAL
- TYPE: Silica (20-30) Sand
- BACKFILL METHOD: grout. Portland Type I by tremie

WELL DEVELOPMENT

- METHOD: Centrifugal pump
- TIME SPENT DEVELOPING: 1 hour
- VOLUME OF WATER REMOVED: 40 gallons
- VOLUME OF WATER ADDED: —
- DESCRIPTION OF PREDEVELOPMENT WATER: gray brown / >100 NTUs
- DESCRIPTION OF POST DEVELOPMENT WATER: gray brown / >100 NTUs

WATER LEVEL SUMMARY

WATER LEVEL MEASUREMENTS (from top of casing)

DATE/TIME	LEVEL
6/19/93 ~3 pm	4.60

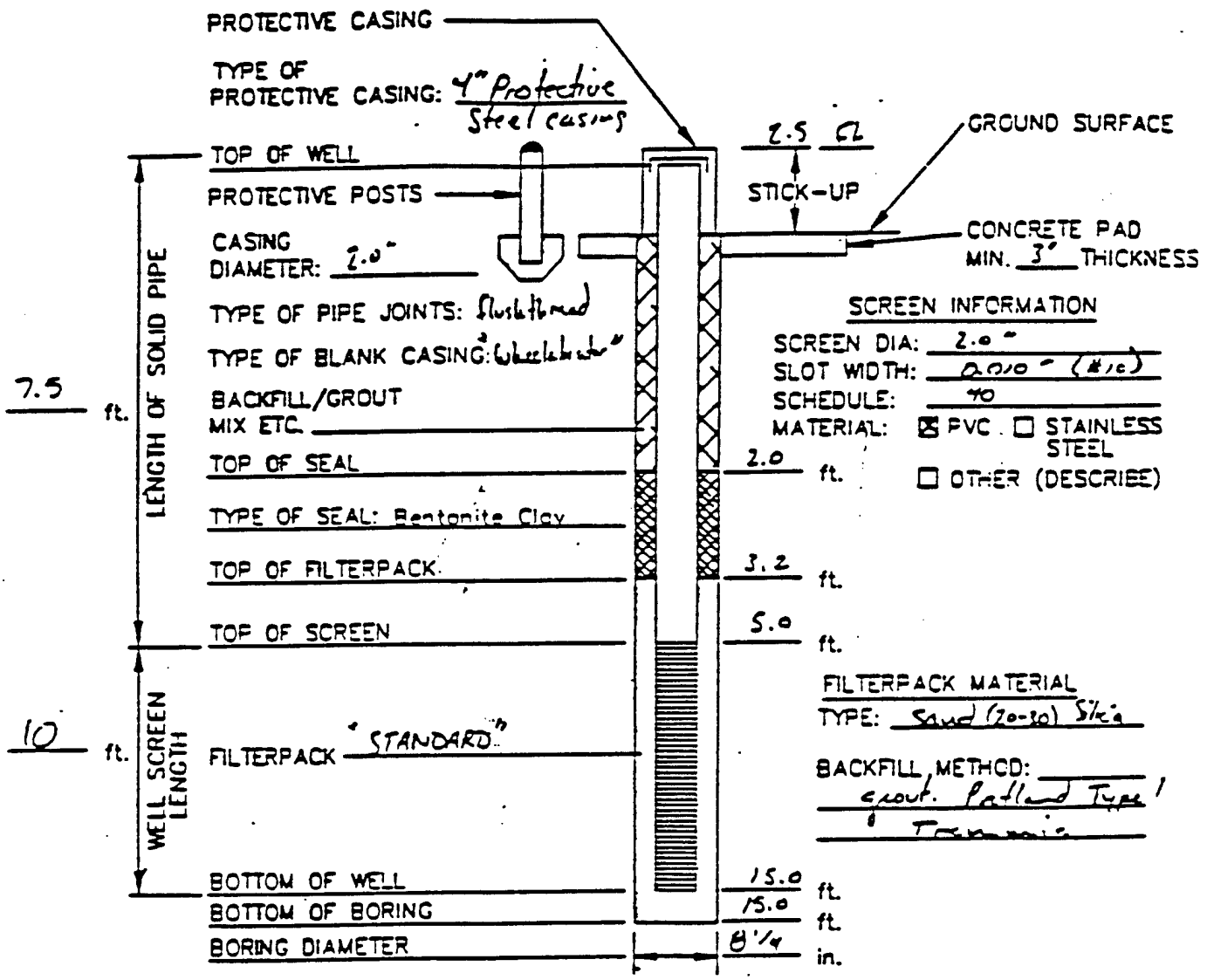
DEPTH FROM TOP CASING AFTER DEVELOPMENT:

5 Turbidity readings

DATE INSTALLED	6-16-93	1100 / 1200	
GROUND ELEVATION	TOP OF CASING ELEVATION 9.88 ft AMSL	SIGNATURE OF INSPECTOR/INSTALLER	
DRILLING METHOD hollow-stem auger		WELL NO. FT23-MW-3	

MONITORING WELL CONSTRUCTION DIAGRAM

(ALL MEASUREMENTS FROM GROUND SURFACE)



SCREEN INFORMATION

SCREEN DIA: 2.0"
SLOT WIDTH: 0.010" (#10)
SCHEDULE: 40
MATERIAL: ☒ PVC ☐ STAINLESS STEEL ☐ OTHER (DESCRIBE)

FILTERPACK MATERIAL

TYPE: Sand (20-30) Silica

BACKFILL METHOD: grout. Portland Type I Tremie

WELL DEVELOPMENT

METHOD: Centrifugal Pump
TIME SPENT DEVELOPING: 1 hour
VOLUME OF WATER REMOVED: 45 gallons
VOLUME OF WATER ADDED:
DESCRIPTION OF PREDEVELOPMENT WATER: gray brown / >100 NTU's
DESCRIPTION OF POST DEVELOPMENT WATER: light gray / 100 NTU's

WATER LEVEL SUMMARY

WATER LEVEL MEASUREMENTS (from top of casing)
DATE/TIME/LEVEL
7.90
6/19/93

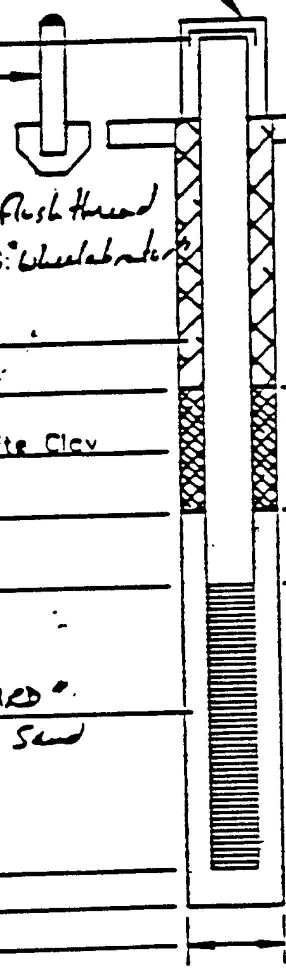
DEPTH FROM TOP CASING AFTER DEVELOPMENT:

Stable readings

ELEVATION GROUND WATER: 1.75 ft Amsl	PROJECT: TYNDALL AFB.
DATE INSTALLED: 6-16-93 / STARTED: 1315 / COMPLETED: 1405	LOCATION (Coordinates or Station)
GROUND ELEVATION: / TOP OF CASING ELEVATION: 11.10 ft amsl	SIGNATURE OF INSPECTOR/INSTALLER: [signature]
DRILLING METHOD: hollow-stem auger	WELL NO. FT25-MW-4

MONITORING WELL CONSTRUCTION DIAGRAM

(ALL MEASUREMENTS FROM GROUND SURFACE)



PROTECTIVE CASING

TYPE OF PROTECTIVE CASING: 4" steel/stickup

TOP OF WELL — 2.5 ft. STICK-UP

GROUND SURFACE

PROTECTIVE POSTS

CONCRETE PAD MIN. 3" THICKNESS

CASING DIAMETER: 2.0

TYPE OF PIPE JOINTS: flush thread

TYPE OF BLANK CASING: Wheelabrator

LENGTH OF SOLID PIPE: 7.5 ft.

BACKFILL/GROUT MIX ETC.

TOP OF SEAL: 2.0 ft.

TYPE OF SEAL: Bentonite Clay

TOP OF FILTERPACK: 3.0 ft.

TOP OF SCREEN: 5.0 ft.

WELL SCREEN LENGTH: 10 ft.

FILTERPACK "STANDARD" 20-30 Sand

BOTTOM OF WELL: 15.0 ft.

BOTTOM OF BORING: 15.0 ft.

BORING DIAMETER: 8¼ in.

SCREEN INFORMATION

SCREEN DIA: 2.0"

SLOT WIDTH: 0.010" (#10)

SCHEDULE: 40

MATERIAL: ☒ PVC ☐ STAINLESS STEEL ☐ OTHER (DESCRIBE)

FILTERPACK MATERIAL

TYPE: Silica Sand (20-30)

BACKFILL METHOD: grout by tremie / portland Type I

WELL DEVELOPMENT

METHOD: Centrifugal Pump

TIME SPENT DEVELOPING: 1 hour

VOLUME OF WATER REMOVED: 45 gallons

VOLUME OF WATER ADDED:

DESCRIPTION OF PREDEVELOPMENT WATER: gray brown / >100 NTUs

DESCRIPTION OF POST DEVELOPMENT WATER: gray / 100 NTUs

WATER LEVEL SUMMARY

WATER LEVEL MEASUREMENTS (from top of casing)

DATE/TIME/LEVEL: 9.35 — 6/19/93

DEPTH FROM TOP CASING AFTER DEVELOPMENT:

greater or less than - 2 stable readings

APPENDIX B

LABORATORY ANALYTICAL REPORTS

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30B1901
Phone: (614) 424-6199
Attn: Matt Place

Alpha Analytical Number: BMI032696-01

Client I.D. Number: TYN-FS-1

Date Sampled: 03/20/96

Date Received: 03/26/96

Compound	Method	Concentration ug/Kg	Detection Limit ug/Kg	Date Analyzed
Benzene	8240	1,800,000	220,000	03/39/96
Toluene	8240	6,000,000	220,000	03/29/96
Total Xylenes	8240	17,000,000	220,000	03/29/96
Ethylbenene	8240	2,700,000	220,000	03/29/96
C-range Compounds	Method	Percentage of Total	Detection Limit (Not Applicable)	Date Analyzed
C07<	GC/FID	32.96	NA	04/03/96
C08	GC/FID	9.22	NA	04/03/96
C09	GC/FID	10.84	NA	04/03/96
C10	GC/FID	10.90	NA	04/03/96
C11	GC/FID	11.70	NA	04/03/96
C12	GC/FID	10.06	NA	04/03/96
C13	GC/FID	7.40	NA	04/03/96
C14	GC/FID	3.91	NA	04/03/96
C15>	GC/FID	3.01	NA	04/03/96

Approved by: Roger L. Scholl Date: 4/4/96

Roger L. Scholl, Ph.D.
Laboratory Director

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.
1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 4/18/96
Client : ALP-855
Taken by: LIENT
Report : 15880
PO# :

Sample	Collected Date	Time	PH S.U.	MOISTURE CONTENT %	KJELDAHL-N MG/L	PHOSPHORUS -TOTAL MG/L	IRON, TOTAL MG/L	DIGESTION-TOTAL METALS
BMI032696-02 - TYN-S-2	3/20/96	:	5.39	18.5	< 0.1 mg/g	40 mg/kg	1.1 mg/g	YES
BMI032696-03 - TYN-S-4	3/27/96	:	5.26	14.1	0.58 mg/g	12 mg/kg	530 mg/kg	YES

Sample	Collected Date	Time	POROSITY %	PARTICLE SIZE DISTIBUTION FRACTION %
BMI032696-02 - TYN-S-2	3/20/96	:	60.7	YES
BMI032696-03 - TYN-S-4	3/27/96	:	51.7	YES

Approved By: _____

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount pai for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

William F. Pillsbury
President

John C. Seher
Manager

Sierra
Environmental
Monitoring, Inc.

June 4, 1996

TO: **Alpha Analytical**

FROM: Sierra Environmental Monitoring, Inc.

RE: Particle Size Distribution Analysis for Samples:

SEM 9603-0626	BMI 032696-02-TYN-S-2
SEM 9603-0627	BMI 033696-03-TYN-S-4

As per your request, we have performed particle size analysis on the samples submitted to our laboratory. Test results for method ASTM D422 are as follows:

9603-0626	Clay: 6.8 %	Silt: 0.0 %	Sand: 93.2 %
9603-0627	Clay: 6.8 %	Silt: 0.0 %	Sand: 93.2 %

The samples were passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

John Seher
Laboratory Manager

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30B1901
Phone: (614) 424-6199
Attn: Matt Place

Sampled: 03/20-22/96 Received: 03/26/96 Analyzed: 03/28/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - EPA Method 624/8240

TPH/BTXE Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
TYN-S-2	TPH	ND	10	mg/Kg
/BMI032696-02	Benzene	51	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Xylenes	ND	20	ug/Kg
TYN-S-4	TPH	15,000	2,500	mg/Kg
/BMI032696-03	Benzene	74,000	5,000	ug/Kg
	Toluene	140,000	5,000	ug/Kg
	Ethylbenzene	69,000	5,000	ug/Kg
	Xylenes	410,000	5,000	ug/Kg

ND - Not Detected

Approved By: Roger L. Scholl Date: 4/5/96
Roger L. Scholl, Ph.D.
Laboratory Director

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30B1901
Phone: (614) 424-6199
Attn: Matt Place

Sampled: 03/24/96 Received: 03/26/96 Analyzed: 03/29/96

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
TYN-DW-1 /BMI032696-04	TPH (Purgeable)	7.4	5.0 mg/L
	Benzene	210	10 ug/L
	Toluene	380	10 ug/L
	Ethylbenzene	150	10 ug/L
	Total Xylenes	1,000	10 ug/L

Approved by: Roger L. Scholl Date: 4/5/96
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. _____

Proj. No.	Project Title
G4622201-30B1901	TYNDALL AFB BIOSCURGER

SAMPLERS: (Signature)

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√)	Container No.	Number of Containers	Remarks
			TPH ASTM BTEX Boiling Pt. Range Total Phosphorus Kjeldahl Nitrogen pH Total Iron Particle-Size Distribution Porosity Moisture Content			
3/20/96	1657	TYN-FS-1	X X		1	FREE PRODUCT
3/20/96		TYN-S-2	X X X X X X X X X X		1	SOIL
3/22/96	1500	TYN-S-4	X X X X X X X X X X		1	SOIL
3/24/96	1630	TYN-DW-1	X X		1	WATER

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	1214 3/25/96				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
			3/26/96 1000		

Billing Information:
Name
Address
City, State, Zip
Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # ___ of ___

Client Name: Battelle	P.O.#: 462201-30B190
Address:	Phone #: (714) 424-6199
City, State, Zip:	Report Attention: Matt Place

Sampled by: Client

Analyses Required

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	BTXE	Boiling Pt. Range Dist.	TPH as [illegible]	Total [illegible]	Kjeldahl [illegible]	pH Total [illegible]	Particle Size	Density/Moisture Content		Remarks
	3/20	OT	BMI032696-01	TYN-FS-1	1	X	X								Fluid (Paint can)
	✓	SO	02	TYN-S-2	1	X		X	X	X	X	X	X		0 RASS
	3/27	✓	03	TYN-S-4	1	X		X	X	X	X	X	X		✓
	3/24	AQ	04	TYN-DW-1	1	X		X							1 VOA
															F

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	[signature]	Linda Bydarick	AAI	3/26/96	1000
Relinquished by	[signature]	Craig Giesy	AAI	3/26/96	4:25
Received by	[signature]	Diane Hill	Chemax	3/26/96	4:25
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: 462201-30B1901
Phone: (614) 424-6199
Attn: Matt Place

Sampled: 03/26/96 Received: 04/02/96 Analyzed: 04/06-09/96

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
TYN-DW-2 MW-5 /BMI040296-01	TPH (Purgeable)	15	0.50 mg/L
	Benzene	22	1.0 ug/L
	Toluene	49	1.0 ug/L
	Ethylbenzene	34	1.0 ug/L
	Total Xylenes	210	1.0 ug/L
TYN-DW-3 -EW-1,2 /BMI040296-02	TPH (Purgeable)	100	25 mg/L
	Benzene	3,800	50 ug/L
	Toluene	3,200	50 ug/L
	Ethylbenzene	1,300	50 ug/L
	Total Xylenes	7,200	50 ug/L

Approved by: Roger L. Scholl Date: 4/11/96
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. _____

Proj. No.	Project Title
42201-308/901	TYNDALL AFB - BIOSURFER

SAMPLERS: (Signature) Matt C.R

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√) T2H (JET FUEL)	SAMPLE TYPE (√) BTEX	Container No.	Number of Containers	Remarks
3/26/96	0905	TYN-DW-2	X	X		1	PRESERVED w/
3/29/96	1630	TYN-DW-3	X	X		1	HCL

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Matt C.R	4/1/96 1342				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
			4/2 0900		

Billing Information:

Name
Address
City, State, Zip
Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name: Battelle
P.O.# 462201-30B1901
Address
Phone #
City, State, Zip
Report Attention: Matt Place

Sampled by: Client

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	Analyses Required: TPH	Analyses Required: BTEX	Remarks
	3/26	OT	BM104029601	TYN-DW-2	1	X	X	VOA
	✓	✓	-02	TYN-DW-3	1	X	X	VOA

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/2/96	0900
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9604022

Work Order Summary

CLIENT:	Mr. Eric Dreschler Battelle Memorial Institute 505 King Avenue Columbus, OH 43201-2693	**BILL TO:** Same	
PHONE:	614-424-3753	**INVOICE #**	10069
FAX:	614-424-3667	**P.O. #**	91221
DATE RECEIVED:	4/2/96	**PROJECT #**	462201-30B1901 Tyndall AFB Bioslurper
DATE COMPLETED:	4/12/96	**AMOUNT$:**	$439.46

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	TYN-0GS-1	TO-3	0 "Hg	$120.00
02A	TYN-0GS-2	TO-3	0.2 psi	$120.00
03A	TYN-0GS-3	TO-3	28.5 "Hg	$120.00
04A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter Summa Canister Preparation (3) @ $15.00 each.	$45.00
	Shipping (3/18/96)	$34.46

CERTIFIED BY: Linda D. Fuerman
Laboratory Director

DATE: 4/12/96

180 BLUE RAVINE ROAD, SUITE B • FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: TYN-0GS-1
ID#: 9604022-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6040413 Date of Collection: 3/24/96
Dil. Factor: 25.2 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.025	0.081	31	100
Toluene	0.025	0.096	17	65
Ethyl Benzene	0.025	0.11	2.8	12
Total Xylenes	0.025	0.11	12	53

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6040413 Date of Collection: 3/24/96
Dil. Factor: 25.2 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.25	1.6	3600	15000
C2 - C4** Hydrocarbons	0.25	0.46	310	570

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: TYN-0GS-2
ID#: 9604022-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6040414 Date of Collection: 3/26/96
Dil. Factor: 498 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.50	1.6	110	360
Toluene	0.50	1.9	240	920
Ethyl Benzene	0.50	2.2	58	260
Total Xylenes	0.50	2.2	240	1000

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6040414 Date of Collection: 3/26/96
Dil. Factor: 498 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	5.0	32	28000	120000
C2 - C4** Hydrocarbons	5.0	9.1	1300	2400

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: TYN-0GS-3

ID#: 9604022-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6040415 Date of Collection: 3/28/96

Dil. Factor: 40.3 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.040	0.13	Not Detected	Not Detected
Toluene	0.040	0.15	Not Detected	Not Detected
Ethyl Benzene	0.040	0.18	Not Detected	Not Detected
Total Xylenes	0.040	0.18	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name: 6040415 Date of Collection: 3/28/96

Dil. Factor: 40.4 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.40	2.6	0.39	1.6
C2 - C4** Hydrocarbons	0.40	0.73	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9604022-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6040406 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6040406 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 4/4/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

@ AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

No 006726

Contact Person AL POLLACK
Company BATTELLE
Address 505 KING AVE. City COLUMBUS State OH Zip 43201
Phone 614 424 3753 FAX 614 424 3667
Collected By: Signature

Project info:
P.O. #
Project # 462201-30B1901
Project Name TYNDALL AFB BIOSWRPCR

Turn Around Time:
☑ Normal
☐ Rush ____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	TYN-OGS-1	3/24/96 - 1546	BTEX, TPH (JET FUEL)	30"	0	0 lbs
02A	TYN-OGS-2	3/26/96 - 0920	BTEX, TPH (JET FUEL)	30"	0	0.2 psi
03A	TYN-OGS-3	3/29/96 - 1050	BTEX, TPH (JET FUEL)	30"	0	28.5" Hg
						4/2/96

Relinquished By: (Signature) Date/Time 4/1/96 Print Name MATT PLACE
Relinquished By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time
Received By: (Signature) Date/Time Scott Amerson ATL 4/2/96 9.44

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	FED EX	6938189495	SA	4/2/96 944	AMBIENT	GOOD	Yes No (None) N/A	9604022

Form 1293 rev. 06

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: FTA-22, TYNDALL AFB

Date: 9/20/96

Operator's Initials: MP

Equipment	Check if Okay	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flow Meter	✓	
Fuel Flow Meter	✓	
Water Flow Meter	✓	
Emergency Shut off Float Switch -Effluent Transfer Tank	✓	
Analytical Field Instrumentation -GasTechtor O_2/CO_2 Analyzer -TraceTechtor Hydrocarbon Analyzer -Oil/Water Interface Probe -Magnehelic Boards -Thermocouple Thermometer	✓	

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Baildown Test Record Sheet

Site: TYNDALL AFB, FL

Well Identification: FTZ3-MW-5

Well Diameter (OD/ID): 2" ID

Date at Start of Test: 3/20/96

Sampler's Initials: MP-GY

Time at Start of Test: 0950

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L
6.89	4.25	2.64	

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
3/20/96-1024	5.33	4.91	0.42
1025	5.31	4.89	0.42
1032	5.26	4.83	0.43
1049	5.23	4.79	0.44
1120	5.35	4.76	0.59
1221	5.48	4.66	0.82
1515	5.59	4.60	0.99
1655	5.64	4.60	1.04
3/21/96-0809	6.17	4.70	1.47

ATMOSPHERIC OBSERVATIONS

Site: TYNDALL AFB FL.
FIRE TRAINING PIT 23

Operators: MATT PLACE, MIKE WOOLFE
GEORGE YU

Date/Time	Ambient Temperature	Relative Humidity	Barometric Pressure
3/21/96 - 0940	57.3° F	12%	—
" - 1437	57.7° F	34%	—
" - 1553	57.7° F	34%	—
3/22/96 - 0734	55.5° F	42%	—
" - 1226	60.7° F	35%	—
" - 1540	58.9° F	36%	—
" - 1811	54.2° F	45%	—
3/23/96 - 0735	54.7° F	40%	—
" - 1500	66.0° F	52%	—
" - 1735	59.4° F	49%	—
3/24/96 - 0850	70.6° F	75%	—
" - 1545	71.3° F	47%	—
3/25/96 - 0750	63.6° F	90%	—
" - 1622	60.7° F	94%	—
3/26/96 - 0747	59.0° F	80%	—
" - 0826	61.4° F	79%	—
" - 1550	70.1° F	71%	—
3/27/96 - 0751	64.0° F	97%	—
" - 1421	66.1° F	98%	—

ATMOSPHERIC OBSERVATIONS

Site: TYNDALL AFB FL. FIRE TRAINING PIT 23

Operators: _____

Date/Time	Ambient Temperature	Relative Humidity	Barometric Pressure
3/27/96 - 1608	67.2°F	98%	—
" - 2150	65.6°F	98%	—
3/28/96 - 0810	62.7°F	98%	
" - 1210	71.1°F	98%	
" - 1815	65.4°F	98%	
3/29/96 - 0810	65.7°F	98%	
" - 1420	74.5°F	98%	
" - 1615	70.4°F	98%	
3/30/96 - 0550	63.6°F	98%	
" - 1645	62.9°F	97%	
3/31/96 - 0555	61.4°F	98%	
" - 1715	61.4°F	98%	
4/1/96 - 0825	58.4°F	78%	

PILOT TEST PUMPING DATA

Site: TYNDALL AFB
FIRE TRAINING PIT 23

Start Date: 3/21/96

Operators: MATT PLACE, MIKE WOOLFE.
GEORGE YU

Start Time: 0940

Test Type: SKIMMER

Well ID: FT23-MW-5

Depth to Groundwater: 6.17'

Depth to Fuel: 4.70'

Depth of Tube: _____

Date/Time	Run Time	Vapor Extraction			Pump Stack Temp (°C)	Pump Head Vacuum (in Hg)	Comments
		Stack Pressure (in H_2O)	Carbon Drums (in H_2O)	Flowrate (scfm)			
3/21 -0940	0	0.06			29.7	20	INITIAL READINGS
-1437		0.09			43.5	18	
-1553		0.55			42.0	18	
3/22-0734		0.065			44.1	18	
-1226		0.11			46.0	17.5	
-1540		NA			44.8	17.75	
-1811		0.095			42.9	18	

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Site: FIRE TRAINING PIT 23 TYNDALL

Start Date: 3/23/96

Operators: MATT PLACE, MIKE WOODFE GEORGE YU

Start Time: 1500

Test Type: SLURPING

Well ID: FT23-MW-5

Depth to Groundwater: _____ Depth to Fuel: _____ Depth of Tube: 8.6'

Date/Time	Run Time	Vapor Extraction			Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. ~~H_2O~~ Hg)
		Stack Pressure (in.-H_2O)	Carbon Drums (in. H_2O)	Flowrate (scfm)			
3/23-1500	0	0.005			26.3	27	8
-1735	2 HR 35 MIN	0.33			32.8	8	0.5
3/24-0850		0.19			34.1	8	0.5
-1545		0.36			35.5	8	NA
3/25-0750		0.35			33.5	8	NA
-1622		0.35			32.1	8	NA
3/26-0747		0.35			33.8	8	NA
-0826		0.005			27.4	26	NA
-1550		0.01			26.2	26	NA
3/27-0751		0.01			25.9	25	9
-1421		0.005			NA	25	10
-1608		0.005			NA	25	NA
-2150		0.01			NA	21	NA
3/28-0810		0.01			NA	NA	NA
-1210		-0.01			NA	25	9
-1815		0.005			NA	25	NA
3/29-0810		0.01			31.7	25	NA
-1420		0.015			31.5	24	NA
-1615		0.00			32.5	24.5	NA
3/30-0550		0.00			29.2	25	NA
-1645		0.001			29.9	25	NA

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Site: FIRE TRAINING PIT 23

Start Date: 3/23/96

Operators: MATT PLACE,

Start Time: 1500

Test Type: Slurping

Well ID: FT23-MW-5

Depth to Groundwater: _____ Depth to Fuel: _____ Depth of Tube: 8.6'

Date/Time	Run Time	Vapor Extraction			Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)
		Stack Pressure (in.-H_2O)	Carbon Drums (in. H_2O)	Flowrate (scfm)			
3/31-0555		0.005			29.3	25	NA
-1715		0.02			34.4	20.5	NA
4/1-0825		0.75			33.4	20	NA

Fuel and Water Recovery Data

Site: Tyndall AFB
Well ID: EW-1, EW-2
Test Type: Vacuum Enhancement

Start Date: 3/28/96
End Date: 3/31/96
Operaters: M. Place, M. Woolfe, G. Yu

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery				F/N
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	
3/28/96 14:52	0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0	
3/28/96 18:15	3.4	7.00	7.0	2.1	2.1	243.20	243.2	71.9	71.9	1.75
3/29/96 8:10	17.3	24.00	31.0	1.7	1.8	1092.00	1335.2	78.5	77.2	1.30
3/29/96 14:20	23.5	8.00	39.0	1.3	1.7	398.00	1733.2	64.5	73.9	1.21
3/30/96 5:50	39.0	24.00	63.0	1.5	1.6	954.00	2687.2	61.5	69.0	1.46
3/30/96 16:45	49.9	12.00	75.0	1.1	1.5	690.00	3377.2	63.2	67.7	1.04
3/31/96 5:55	63.1	20.00	95.0	1.5	1.5	811.00	4188.2	61.6	66.4	1.46
Total Time (hours)	63.05	Rate (gph)	1.51	Rate (gpd)	36.16	Rate (gph)	66.43	Rate (gpd)	1594.24	

Fuel and Water Recovery Data

Site: Tyndall AFB
Well ID: MW-5
Test Type: Skimmer

Start Date: 3/21/96
End Date: 3/22/96
Operaters: M. Place, M. Woolfe, G. Yu

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
3/21/96 9:40	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0
3/21/96 15:53	6.2	2.08	2.1	0.3	0.3	100.00	100.0	16.1	16.1
3/22/96 7:34	21.9	0.04	2.1	0.0	0.1	185.00	285.0	11.8	13.0
3/22/96 12:26	26.8	0.05	2.2	0.0	0.1	63.10	348.1	13.0	13.0
3/22/96 15:40	30.0	0.03	2.2	0.0	0.1	25.00	373.1	7.7	12.4
3/22/96 18:11	32.5	0.03	2.2	0.0	0.1	15.00	388.1	6.0	11.9
Total Time (hours) 32.52		Rate (gph) 0.07		Rate (gpd) 1.64		Rate (gph) 11.94		Rate (gpd) 286.45	

Fuel and Water Recovery Data

Site: Tyndall AFB
Well ID: MW-5
Test Type: Vacuum Enhancement

Start Date: 3/23/96
End Date: 3/27/96
Operaters: M. Place, M. Woolfe, G. Yu

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
3/23/96 15:00	0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0
3/23/96 17:35	2.6	0.00	0.0	0.0	0.0	366.60	366.6	141.9	141.9
3/24/96 8:50	17.8	0.05	0.1	0.0	0.0	535.30	901.9	35.1	50.6
3/24/96 15:45	24.8	0.00	0.1	0.0	0.0	241.90	1143.8	35.0	46.2
3/25/96 7:50	40.8	0.00	0.1	0.0	0.0	556.70	1700.5	34.6	41.6
3/25/96 16:22	49.4	0.01	0.1	0.0	0.0	340.10	2040.6	39.9	41.3
3/26/96 7:47	64.8	0.01	0.1	0.0	0.0	619.90	2660.5	40.2	41.1
3/26/96 15:50	72.8	0.00	0.1	0.0	0.0	287.40	2947.9	35.7	40.5
3/27/96 7:51	88.8	0.25	0.3	0.0	0.0	1023.00	3970.9	63.9	44.7
3/27/96 16:08	97.1	0.20	0.5	0.0	0.0	896.30	4867.2	108.2	50.1
Total Time (hours)	97.13	Rate (gph)	0.01	Rate (gpd)	0.13	Rate (gph)	50.11	Rate (gpd)	1202.60

Fuel and Water Recovery Data

Site: Tyndall AFB
Well ID: MW-5
Test Type: Drawdown

Start Date: 3/27/96
End Date: 3/28/96
Operaters: M. Place, M. Woolfe, G. Yu

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
3/27/96 17:52	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0
3/27/96 21:50	4.0	0.01	0.0	0.0	0.0	144	144.0	36.3	36.3
3/28/96 8:10	14.3	0.51	0.5	0.0	0.0	1145	1289.0	110.8	90.1
3/28/96 12:10	18.3	0.00	0.5	0.0	0.0	394	1683.0	98.5	92.0
3/28/96 14:48		No Data				No Data			
Total Time (hours)	20.93	Rate (gph)	0.03	Rate (gpd)	0.60	Rate (gph)	80.40	Rate (gpd)	1929.55

Fuel and Water Recovery Data

Site: Tyndall AFB
Well ID: MW-5
Test Type: Drawdown

Start Date: 3/31/96
End Date: 4/1/96
Operaters: M. Place, M. Woolfe, G. Yu

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
3/31/96 6:40	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0
3/31/96 17:15	10.6	1.00	1.0	0.1	0.1	701	701.0	66.2	66.2
4/1/96 8:25	25.7	0.00	1.0	0.0	0.1	853	1554.0	56.2	60.3
Total Time (hours)	25.75	Rate (gph)	0.04	Rate (gpd)	0.93	Rate (gph)	60.35	Rate (gpd)	1448.39

Record Sheet for In Situ Respiration Test

Site FIRE TRAINING PIT 23	Monitoring Point A
Shutdown Date 4/1/96	O_2/CO_2 Meter No. / TPH Meter No.
Shutdown Time 0910	Recorded by George Yu

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
4/1/96	0915	21	0	234	1.4	—	
	0920	20.5	0	240	1.5	—	
	1235	19.5	0	1000	1.4	—	
	1450	19	0.5	1240	1.5	—	
	1720	17.5	0.5	1840	1.4	—	
	2305	11	0.75	3800	1.7	—	
4/2/96	0425	4.0	1.5	12000	1.8	—	
5	0900	2.5	2.0	20000	1.6	—	

INSITU.RS (G462201-1001 DISK)

Record Sheet for In Situ Respiration Test

Site FIRE TRAINING PIT 23		Monitoring Point B	
Shutdown Date 4/1/96		O_2/CO_2 Meter No.	TPH Meter No.
Shutdown Time 0910		Recorded by George Yo	

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
4/1/96	0915	21	0	78	1.5	—	
	0920	19.5	0	238	1.4	—	
	1235	18	0.5	1800	1.4	—	
	1450	16	0.75	2800	1.5	—	
	1720	14	1.0	4800	1.6	—	
	2305	9.5	1.5	10400	1.6	—	
4/2/96	0425	6.5	2.5	16800	1.7	—	
S	0900	4.5	3.0	>20000	1.6	—	

INSITU.RS (G462201-1001 DISK)

Record Sheet for In Situ Respiration Test

Site FIRE TRAINING PIT 23	Monitoring Point D
Shutdown Date 4/1/96	O_2/CO_2 Meter No. / TPH Meter No.
Shutdown Time 0910	Recorded by George Yu

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
4/1/96	0915	21	0	220	1.6	–	
	0920	20	0	220	1.4	–	
	1235	19.5	0	760	1.4	–	
	1450	18.5	0.25	1040	1.4	–	
	1720	17.5	0.5	1380	1.5	–	
	2305	14.5	0.75	2000	1.6	–	
4/2/96	0425	9.0	0.75	3200	1.7	–	
S	0900	7.0	1.0	4400	1.7	–	

INSITU.RS (G462201-1001 DISK)

Record Sheet for In Situ Respiration Test

Site FIRE TRAINING PIT 23		Monitoring Point E	
Shutdown Date 4/1/96		O_2/CO_2 Meter No.	TPH Meter No.
Shutdown Time 0910		Recorded by George Yu	

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
4/1/96	0915	21	0	220	1.1	—	
	0920	19.5	0	262	1.5	—	
	1235	18.	0.5	1400	1.4	—	
	1450	16.5	0.75	2000	1.3	—	
	1720	15.5	0.75	2800	1.5	—	
	2305	12.5	1.25	5200	1.6	—	
4/2/96	0425	11.0	1.5	6800	1.6	—	
"	0900	11.0	1.5	6000	1.6	—	

INSITU.RS (G462201-1001 DISK)

APPENDIX E

SOIL GAS PERMEABILITY TEST RESULTS

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 4/13/96 /1338
DISTANCE FROM VENT WELL (ft. & tenths)	10'	20'	30'	12'	SITE: FT PIT 23, TYNDALL AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: George Yu, Mike Wolfe
	MP-A	MP-B	MP-C	MP-D	COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
1338 - INITIAL	0.0	0.0	0.0	0.0	
1339 - 1 min	0.250	-0.010	0.000	-0.020	
- 2 min	0.600	0.090	0.100	-0.020	
- 3 min	0.600	0.090	0.500	-0.005	
- 4 min	1.000	0.240	0.500	-0.015	
- 5 min	1.000	0.240	0.750	0.055	
- 6 min	1.000	0.240	0.750	0.080	
1345 - 7 min	1.000	0.240	0.750	0.120	
1346 - 8 min	1.000	0.490	0.750	0.155	
1347 - 9 min	5.000	0.980	1.000	-	
1348 - 10 min	3.000	0.990	1.280	0.265	
1353 - 15 min	4.000	1.420	0.850	0.495	
1358 - 20 min	7.000	1.420	0.850	0.645	
1403 - 25 min	9.000	2.240	0.850	0.845	

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 4/13/96 /1338
DISTANCE FROM VENT WELL (ft. & tenths)	10'	20'	30'	12'	SITE: FT PIT 23 TYNDALL AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY:
	MP-A	MP-B	MP-C	MP-D	COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
1408 - 30min	10.000	2.990	0.900	0.995	
1413 - 35min	11.000	3.240	1.320	1.095	
1418 - 40min	11.000	4.240	1.470	1.245	
1423 - 45min	13.000	5.240	1.670	1.345	
1428 - 50min	13.000	6.240	1.425	0.685	
1438 - 60min	14.000	7.240	2.950	1.545	
1453 - 75min	16.000	7.240	3.250	1.695	
1508 - 90min	17.000	8.240	3.500	1.795	
1523 - 105mm	18.000	8.240	4.500	1.895	
1538 - 120min	18.000	9.240	4.500	1.945	
1608 - 150min	19.000	9.240	4.500	2.045	

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 4/13/96 1338
DISTANCE FROM VENT WELL (ft. & tenths)	23'	40'			SITE: FT PIT 23 TYNDALL AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY:
	MP-E	MP-F			COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
1338 · INITIAL	0.0	0.0			
1339 - 1 min	-0.035	-0.010			
1340 - 2 min	-0.030	-0.010			
1341 - 3 min	-0.030	-0.010			
1342 - 4 min	-0.015	0.020			
1343 - 5 min	-0.015	0.020			
1344 - 6 min	0.000	0.025			
1345 - 7 min	0.000	0.025			
1346 - 8 min	0.020	0.025			
1347 - 9 min	—	—			
1348 - 10 min	0.035	0.015			
1353 - 15 min	0.070	0.020			
1358 - 20 min	0.150	0.025			
1403 - 25 min	0.215	0.020			

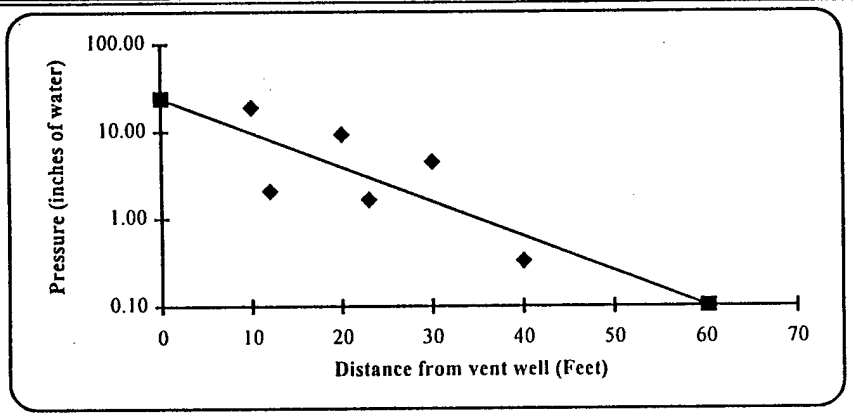
BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 4/13/96 / 1338
DISTANCE FROM VENT WELL (ft. & tenths)	23'	40'			SITE: FT PT 23, TYNDALL
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY:
	MP-E	MP-F			COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
1408 - 30min	0.340	0.025			
1413 - 35min	0.420	0.050			
1418 - 40min	0.550	0.075			
1423 - 45min	0.625	0.095			
1428 - 50min	0.685	0.060			
1438 - 60min	0.785	0.100			
1453 - 75min	1.085	0.160			
1508 - 90min	1.285	0.225			
1523 - 105min	1.435	0.240			
1538 - 120min	1.485	0.270			
1608 - 150min	1.635	0.325			

Radius of Influence

Site Name Tyndall AFB **Operator(s)** M. Woolfe, G. Yu **Date:** 4/2/96

Time (min.)	Air Flow (cfm)	Vacuum (inches of water)													
		MP-A	MP-B	MP-C	MP-D	MP-E	MP-F								
0.00		0.00	0.00	0.00	0.00	0.00	0.00								
3.00		0.60	0.09	0.50	-0.01	-0.03	-0.01								
5.00		1.00	0.24	0.75	0.06	-0.02	0.02								
10.00		3.00	0.99	1.28	0.27	0.04	0.02								
30.00		10.00	2.99	0.90	1.00	0.34	0.03								
90.00		17.00	8.24	3.50	1.80	1.29	0.23								
150.00		19.00	9.24	4.50	2.05	1.64	0.33								
Distance (ft)		10.00	20.00	30.00	12.00	23.00	40.00								

R_I: 60.25 ft



APPENDIX F

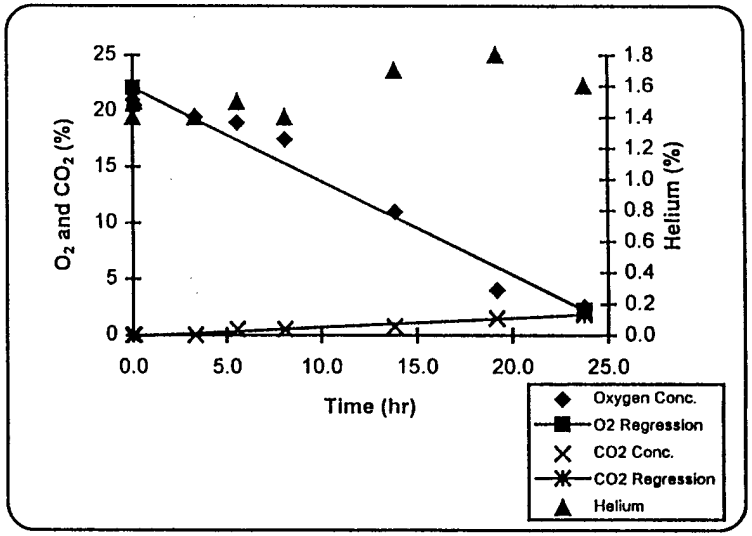
IN SITU RESPIRATION TEST RESULTS

Respiration Tests

Date: 4/1/96 **Site Name:** Tyndall AFB

Monitoring Point: MP-A **Depth of M.P. (ft):** 3'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
4/1/96 9:15	0.0	21.00	0.00	1.40
4/1/96 9:20	0.1	20.50	0.00	1.50
4/1/96 12:35	3.3	19.50	0.00	1.40
4/1/96 14:50	5.6	19.00	0.50	1.50
4/1/96 17:20	8.1	17.50	0.50	1.40
4/1/96 23:05	13.8	11.00	0.75	1.70
4/2/96 4:25	19.2	4.00	1.50	1.80
4/2/96 9:00	23.8	2.50	2.00	1.60



Biodegradation Rate (mg/kg/day)

32.203

O_2 Utilization Rate

Ko	0.014 %/min
	0.836 %/hr
	20.061 %/day

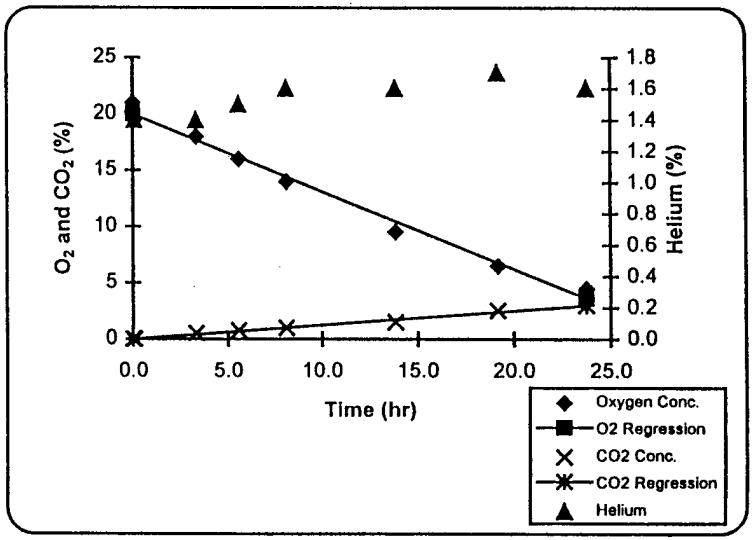
Regression Lines	O_2	CO_2
Slope	-0.8359	0.0820
Intercept	22.0895	-0.1003
Determination Coef.	0.9617	0.9540
No. of Data Points.	8	8

Respiration Tests

Date: 4/1/96 Site Name: Tyndall AFB

Monitoring Point: MP-B Depth of M.P. (ft): 3'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
4/1/96 9:15	0.0	21.00	0.00	1.50
4/1/96 9:20	0.1	19.50	0.00	1.40
4/1/96 12:35	3.3	18.00	0.50	1.40
4/1/96 14:50	5.6	16.00	0.75	1.50
4/1/96 17:20	8.1	14.00	1.00	1.60
4/1/96 23:05	13.8	9.50	1.50	1.60
4/2/96 4:25	19.2	6.50	2.50	1.70
4/2/96 9:00	23.8	4.50	3.00	1.60



Biodegradation Rate (mg/kg/day)

26.595

O_2 Utilization Rate

Ko	0.012 %/min
	0.690 %/hr
	16.568 %/day

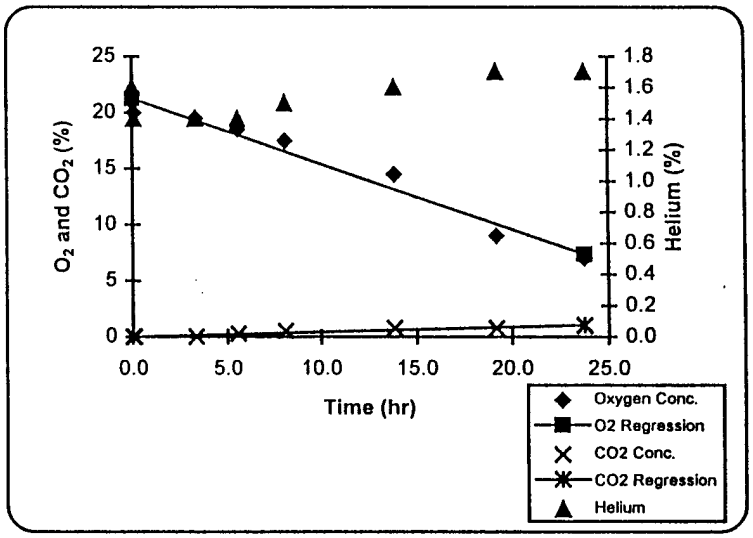
Regression Lines	O_2	CO_2
Slope	-0.6903	0.1247
Intercept	19.9960	0.0050
Determination Coef.	0.9877	0.9914
No. of Data Points.	8	8

Respiration Tests

Date: 4/1/96 **Site Name:** Tyndall AFB

Monitoring Point: MP-D **Depth of M.P. (ft):** 3'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
4/1/96 9:15	0.0	21.00	0.00	1.60
4/1/96 9:20	0.1	20.00	0.00	1.40
4/1/96 12:35	3.3	19.50	0.00	1.40
4/1/96 14:50	5.6	18.50	0.25	1.40
4/1/96 17:20	8.1	17.50	0.50	1.50
4/1/96 23:05	13.8	14.50	0.75	1.60
4/2/96 4:25	19.2	9.00	0.75	1.70
4/2/96 9:00	23.8	7.00	1.00	1.70



Biodegradation Rate (mg/kg/day)

22.551

O_2 Utilization Rate

Ko	0.010 %/min
	0.585 %/hr
	14.048 %/day

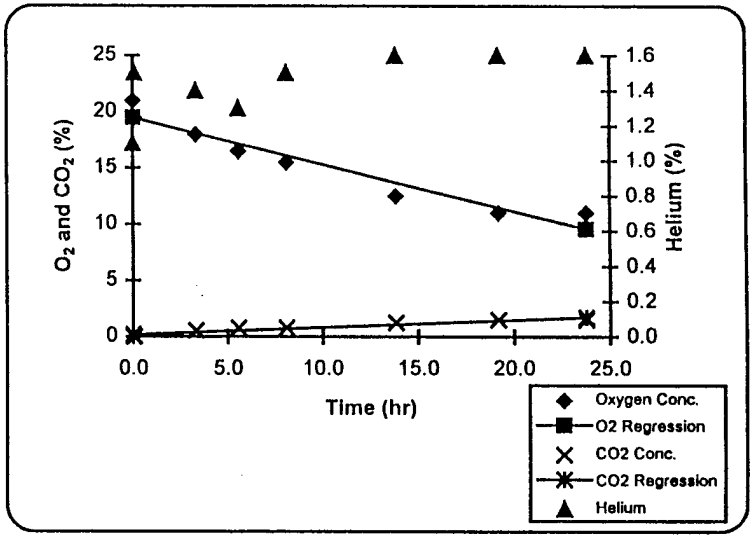
Regression Lines	O_2	CO_2
Slope	-0.5853	0.0436
Intercept	21.2773	0.0037
Determination Coef.	0.9702	0.9347
No. of Data Points.	8	8

Respiration Tests

Date: 4/1/96 **Site Name:** Tyndall AFB

Monitoring Point: MP-E **Depth of M.P. (ft):** 3'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
4/1/96 9:15	0.0	21.00	0.00	1.10
4/1/96 9:20	0.1	19.50	0.00	1.50
4/1/96 12:35	3.3	18.00	0.50	1.40
4/1/96 14:50	5.6	16.50	0.75	1.30
4/1/96 17:20	8.1	15.50	0.75	1.50
4/1/96 23:05	13.8	12.50	1.25	1.60
4/2/96 4:25	19.2	11.00	1.50	1.60
4/2/96 9:00	23.8	11.00	1.50	1.60



Biodegradation Rate (mg/kg/day)

16.113

O_2 Utilization Rate

Ko	0.007 %/min
	0.418 %/hr
	10.037 %/day

Regression Lines	O_2	CO_2
Slope	-0.4182	0.0654
Intercept	19.4849	0.1777
Determination Coef.	0.9334	0.9190
No. of Data Points.	8	8